THE DIGITAL TUTOR, AN EDUCATIONAL TECHNOLOGY MARVEL: A FUTURISTIC ANALYSIS OF A MODERN INTELLIGENT TUTORING SYSTEM USING SOFT SYSTEM METHODOLOGY

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The COVID-19 pandemic wiped off decades of educational gains in the developing world and added 24 million more children to 775 million illiterates in the world. To counteract such a huge predicament, human learning agility comes into action. This human characteristic of knowing what to do when one does not know what to do, invokes the Soft System Methodology (SSM) approach to analyze illiteracy as the worst of all pandemics since it infiltrates into generations. After evaluating different effective teaching methods and utilizing the SSM approach, this paper proposes suitable pedagogies to educate deprived students. It examines Massive Online Open Courseware (MOOC) as a viable solution for K-12 students and compares it with a more robust educational technology model of Intelligent Tutoring System (ITS). Using artificial intelligence, the ITS tailors the instructional content framework and teaching strategies after evaluating students' pre-existing knowledge, learning habits, & styles. The ITS engages the student with the lesson with a two-way dialog while providing customized instruction and immediate feedback. An ITS requires no human intervention and could be a suitable replacement for an inadequately qualified teacher or no teacher. Hence it could be a practical tool in tackling the global literacy catastrophe. A comprehensive literature review followed by a meta-analysis reveals the effectiveness of ITS as a feasible intervention. The major purpose of this study is to define the application of educational pedagogy behind AI-based tutoring and cognitive science in this learner-centered approach.

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In the end, I want to extend my heartful thanks and deep gratitude to my wife, who bestowed her love and unconditional support. Thank you very much, Nosha Jee. This was the journey we walked together to carry the legacy of our beloved deceased daughter, Zahra Khan.

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CHAPTER 1

INTRODUCTION

Summary

This manuscript-style dissertation proposes a conceptual learning model based on the author's published work and integrated literature review. This conceptual framework does not rely on the conventional interpretive context. Instead, the dissertation uses a three-manuscript style, with an ultimate goal to interpret an AI-based educational technology that could be used as an intervention in educating millions of underprivileged K-12 students. Unfortunately, these students are deprived of quality education due to adverse events or improper educational resources like inadequately trained teachers, schools, or even no school or teachers. The three manuscripts included in this dissertation are adapted based on three published or research papers by the author.

Research Questions

The three manuscripts in this dissertation are being applied to find the answers to the following questions?

1. Whether an ITS could be used as a viable intervention to deliver education in the developing world?
2. Which educational pedagogy would be best suited for distant learners?
3. What are the challenges in delivering implementing this educational technology in developing nations?

The first manuscript, "The Digital Tutor: A Concept, A Passion, A Reality - An Intelligent Solution to the World's Illiteracy Menace," was presented jointly at the 2019 E-Learn Conference at New Orleans. Adil Khan, Jennie Johnson, and Courtney Dela Cruz. were the authors, and it was published in the AACE (2019) conference proceedings.

The paper comprehensively reviews the Universal Declaration of Human Rights (UDHR) Article – 26, the Right of Education for all. First, it discusses how many of the signatory nations failed to protect this right of their citizens. Next, it discusses MOOCs as a possible educational source for educating the masses. The advantages of this free educational portal were reviewed, and its limitations were evaluated due to its unstructured scholastic model for school-age children. Subsequently, the Intelligent Tutoring System (ITS) features were discussed, and a case was built to use ITS as a viable educational technology intervention in educating the masses. Finally, the components of the virtual pedagogical agent, Digital Tutor (DT), the face of ITS that interacts with the learner, were discussed.

The second paper, "The Digital Tutor and Student Engagement Techniques - An Intelligent Way to Engage Students in ITS," was presented at the Innovate Learning Summit 2020. Later on, it was published by the Association for the Advancement of Computing in Education (AACE). Adil Khan, Dr. Rose Baker, Douglas Ayega, and Isabela Aguilar jointly co-authored the paper. The presentation was also published in the refereed AACE (2020) conference.

The paper mainly discusses the importance of the learner's engagement in the lesson, which enhances students' attention, heightens focus, stimulates critical thinking, and bolsters meaningful learning. Additionally, it establishes a connection between student engagement and success, a critical element in a learning environment. Later, it discusses the essential role of emotions in the learning process. Fear, frustration, anxiety, and depression can lead to boredom and non-clarity of the concept, resulting in students' disengagement from the lesson. The ITS is designed to simulate a human tutor in a student-centered adaptive teaching and learning environment. In any withdrawal from the lesson, the DT, the virtual pedagogical agent in the ITS

(User Interface Model), reengages the learner with a two-way dialog using gaze patterns, emotion recognition, voice recognition, and voice cloning technology. In doing so, the ITS promotes motivation that helps in the learning process.

The third manuscript, "The Digital Tutor: An Educational Technology Marvel. A Futuristic Analysis of a Modern Intelligent Tutoring System," is a co-authorship of Adil Khan, Drs. Rose Baker, and Robert Wright. The paper is expected to be presented at the AACE's 2021 SITE-Interactive Conference. A proposal to the venue has been submitted and awaiting approval.

This paper explains how human instinct, Learning Agility, comes into play when faced with a complex problematic situation and does not know what to do. The overwhelming task of educating additional underprivileged school-age children, who were added to the existing list of millions, the learning agility, invokes Soft System Methodology (SSM) approach to find a possible course of action. The paper briefly throws light on learning agility and the SSM approach. Then, the two aspects are discussed in detail, including the seven stages of SSM, in the "Introduction" section of this dissertation, along with the rationales behind this research.

The authors then build a case for a promising global literacy intervention using ITS. An intervention at this level requires systematic research before any implementation. The ITS works on the idea of "diagnose errors and tailor remediation based on the diagnosis" (Shute & Psotka, 1994). A comprehensive literature review is carried out on different ITS types used in the field. A meta-analysis of multiple studies was performed to examine its effectiveness as a feasible intervention. One of the major purposes of this manuscript is to study the application of educational pedagogy behind the concept of AI-based tutoring and cognitive science in this learner-centered approach.

This intervention in educating underserved children results from learning agility, and the

application of Soft System Methodology is analyzing and solving a problematic situation.

The Relationship

The motivation behind these three manuscripts is the passion for educating the underprivileged. There is no reason that the poor shouldn't get their Right to Education fulfilled. Unfortunately, quality education has become a profit-making business, and only the rich can afford it in developing countries. The three manuscripts are an effort to make education within reach of all. The first paper establishes alertness of the illiteracy issue and discusses current educational technology elements being used in the field. Since educating children in multiple remote regions of the world is an expensive and difficult task, an AI-based innovation, the ITS, was introduced as an educational tool.

The second paper boasts some innovative features of an ITS by comparing them with a human tutor. It discusses the importance of student engagement in the learning process. In the absence of a human figure in the learning environment, it will not be easy to keep the learner connected with the lesson. The ITS recognizes student boredom and "zoning out "of the lesson using emotion recognition, gaze patterns, voice cloning and reengages the learner with a two-way dialog. All of these tasks are performed effectively using Ai-based technologies without any human intervention.

The third paper promotes ITS with statistical analysis. First, it builds a case for ITS with empirical research by comparing multiple studies on the topic. Second, a meta-analysis was conducted to see if an ITS is effective or not as a mode of education delivery. Finally, the results were compiled with charts and data. This task concluded that an ITS could be an innovative educational intervention to help eradicate illiteracy.

Author's Contribution

The first manuscript was co-authored by Adil Khan, Dr. Robert Wight, and Dr. Jennie Johnson. The first author had the role of the principal investigator. With Dr. Wrights' supervision, Khan and Johnson did the research and data collection. After reviewing necessary documents, all authors deliberated on a framework for the article, and the articulation resulted in a published document. It was presented at the conference by Khan. The presentation received a "Greatest Impact in Field" award.

In the second manuscript, Khan was again the principal investigator, with Dr. Baker as the co-investigator. Multiple papers on the topic were reviewed, and the two authors collectively scribed the research. Isabel Aguilar presented the paper at the conference, with all authors present. Douglas Ayega took care of the administrative issues and helped to format the paper.

The third manuscript required the most comprehensive research. Hundreds of published and unpublished journal articles, books, book chapters, thesis, dissertations, and declassified documents were reviewed. Khan did the research and collected data, Drs. Wright and Baker provided guidance and mentorship. The data was compiled after multiple discussions, and Khan performed the meta-analysis. Khan then wrote the paper under Drs. Wright's and Baker's supervision. The three authors agreed to co-present the paper at the AACE's SITE Innovate conference in October 2021.

Khan's contribution to this research was to intervene as a global organization developer and improve the system of interest, a soft system analyst to expose a very serious problematic situation, and a global project manager to implement a possible solution. Unfortunately, people within the system get used to the problematic situation, which becomes a norm of their lives. The author performs this research as an awareness effort to educate all the stakeholders of the system

of interest (SOI) and understand that if illiteracy is not solved, it will infiltrate deeply into generations. With scientific evidence through meta-analysis, the author is convincing to incorporate artificial intelligence in educational practices to eradicate illiteracy from the world. The author comes as an educational scholar, a global system analyst, a universal project manager, or maybe a reformer who argues scientifically that the world has to rise collectively to pull the deprived fellow humans out of their problematical situation. Instead of just a critique, the author demonstrated systematic research and established statistical analysis reports that possible solutions are available for the problem. This dissertation is expected to serve as a guideline to current and future educators.

Introduction

The Universal Declaration of Human Rights (UDHR, 1948) unanimously protects fundamental human rights. Although the signatory member states (previous and current) had good faith in guarding their citizens' fundamental rights, unfortunately, the promised priorities slowly eroded in almost two-thirds of the nations (WJP Index, 2018). In the recent past, the world has seen the biggest decline in the Right of Freedom & Security, Freedom of Expression and Religion, Right of Health & well-being, and the Right of Education.

Even though the global literacy rate has increased from 42% in 1960 to 86% in 2019 (Statista, 2021), many developing nations are still illiterate even after 74 years of the UDHR agreement. Despite numerous efforts by the world's educational and humanitarian organizations, the illiteracy rate among the Sub-Saharan Africa population hovers around 34.7%, and South Asia 27.1% (Statista, 2021). On the other hand, the literacy rate in countries like Chad (22.31%), South Sudan (27%), Afghanistan (28%) saw a further decline (World development indicators, 2019). There were 773 million illiterates in the world before the COVID-19 pandemic started

(UNESCO Institute of Statistics, 2018). The latest figures are more than devastating. As of March 2020, 89% of the world's school population (1.52 billion children and youth, 743 million girls) was out of school (UNESCO, 2020). The World Bank reported that 72 million additional primary students would suffer from learning poverty ("72 million additional," 2020). UNESCO (2021) reported that one year into COVID wiped off two decades of educational gains and resulted in a sharp (20%) rise from 460 million to 584 million in reading difficulty among children. Besides poverty, other causes of illiteracy are; preference to work, over education, child labor, geographical factors, poor implementation of an educational program, cultural Influences (min reason of the female low literacy rate in rural Pakistan and Afghanistan).

Applying the Soft-System Approach to Undertake the Problematic Situation

With one-sixth of the world illiterate, we have a massive problem with dreadful consequences to humanity. Educating hundreds of millions is more than an overwhelming challenge. To undertake such an immense task, the traditional methodology for the solution may not be feasible. We would have to take a different approach, and that is the "Soft System Methodology." Peter Checkland developed the soft system methodology (SSM) in the 1990s. It contemplates and analyzes a complex situation and intervenes in a possible solution with a consensus of all stakeholders.

Understanding the problem is half the solution; actually, the better half. We can apply a systems approach in defining a problem. "The SSM is a cyclic learning system that uses models of human activity to explore with the actors in the real-world problem situation, their perceptions of that situation, and their readiness to decide upon purposeful action which accommodates different actors' perceptions, judgments, and values" (Checkland, 1999). The SSM attempts to foster learning and appreciation of the problematic situation rather than solve a predefined

problem. We already know the real-world problem (present state – S_0), and a possible solution exists (desired state – S_1). With Peter Checkland's method (1991), the study undertakes an approach in learning and appreciation of the complicated situation, determines that the complex situation is problematic, expresses the problem situation with historical and real-world situations, derive root definitions of relevant systems, and provides an intervention framework for tackling such situations. While introducing the SSM approach in the world's illiteracy problem, we look into Jay Foster's (1950) system dynamics methodology, which uses mathematical modeling techniques to recognize complex challenges and frame possible solutions (Radzicki and Taylor, 2018). Peter Senge (1990), on the other hand, discusses the five disciplines of learning an organization, which include (1) Shared Vision, (2) Mental Models, (3) Team Learning, (4), Personal Mastery (5), and System Thinking (5). Senge suggested that while analyzing an organization, recognize the whole perspective of the problem, rather than isolated and small controllable components.

To educate millions of deprived students, the system of interest (SOI) requires a soft system approach to evaluate the current situation of illiteracy. The soft system approach needs to evaluate the 7 - Ws of research: Who, What, Where, in What way, Why, When, and for Whom? The core purpose of these 7 - Ws analyses is to find and improve the current problematic situation. The answer to these Ws lies in the deep understanding of the SOI and exploring why and how it acquired this problematic situation. The evaluation shows that the root causes are poverty, lack of interest in education, inadequate educational programs, child labor, societal and cultural norms. A viable solution would require a robust intervention using educational technology.

The 7 Ws of SOI

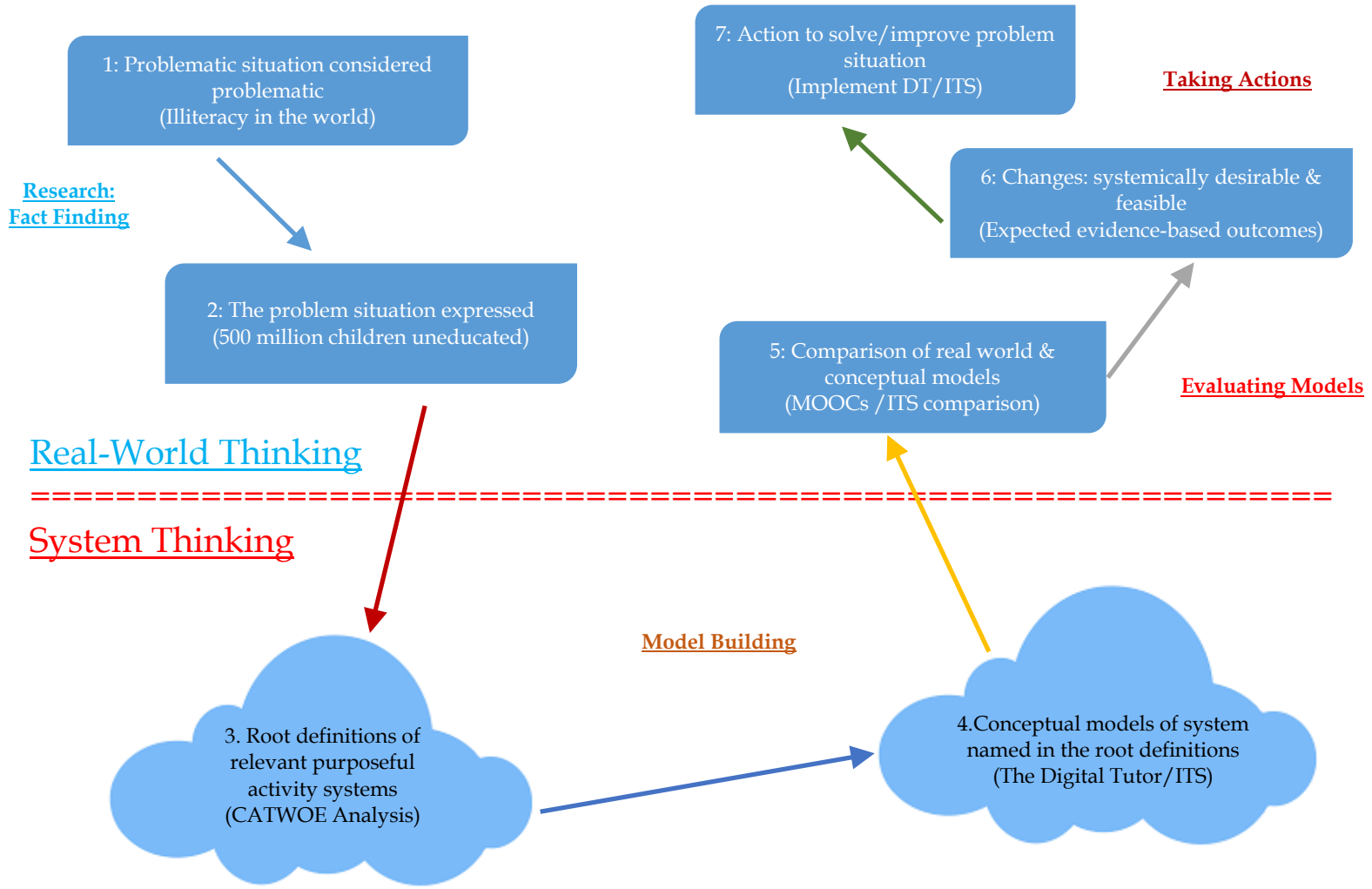
- Why? The answer of "Why" is the main purpose of the soft system analysis of the troubled illiteracy among the children. The objective is to determine the system's flaws and failures and provide quality education to all the students in the regions of interest.
- Who will benefit from this SSM?

The underprivileged students of Sub-Saharan Africa, Latin America, and many other children of the developing nations. These children cannot afford quality education, which is only available to the rich class of citizens.

- What is needed to be done? First, analyze all the components of the system. Then, find the flaws by looking into the backgrounds which led to these deficiencies and imperfections. What are the reasons, the history behind them, the interests (or lack thereof) of the stakeholders, the detrimental practices, and the lack of passion for helping people improve their lives? Also, analyze the culture that is prohibiting the education of females in the rural world.
- Where to start the analysis? In the poor regions of the world. Conduct a literature review, read historical documentation, observations, and surveys; review educators' writings, sift through the reports of concerned international and governmental philanthropical organizations. Analyze education systems and the applications of educational technologies in the field. Check for interventions that worked and didn't. Find constraints, distractions, interruptions, and other details.
- In what way? How would you start your research? Who would be involved?
- When? As soon as possible. The world's children are waiting. When would you start the SSM approach? What motivation and interest you have in doing this SSM?
- For whom? The literate world. .

Figure 1.1

Soft System Methodology Explained



A possible intervention requires exploring the SOI from a different angle. For example, the SSM intervention would be needed to:

- Determine the situation
- Think about different systems which could or could not be employed in the situation
- Measure the thinking of the systems
- Take action depending on previous information learned
- Build conceptual models
- Compare it to other systems in the real world.
- Formulate the problem situation
- Determine the root causes
- And define a possible solution.

The fundamental concept incorporated in SSM is to keep the wholeness of the system. The analysis of SOI would require elaborating the first three steps of the SSM model, as shown in Figure 1.1.

SSM intervention is needed to break down the issue, develop a clear structure of the problem, create the conceptual model, compare it with real-world situations, formulate possible changes, and recommend action involving all stakeholders.

The Problem Situation Expressed: A Real-World Problematic Situation Analysis

Illiteracy is a destitute international crisis. It exposes ignorance to basic human rights: poverty, poor living conditions, physiological and psychological disorders, and many sociological and civic problems could be the result. Some of the major causes of illiteracy are poverty and inequality, child labor, poor implementation of educational programs, and cultural influences. Poverty Research Center (CPRC, n.d.) reports that the menace of poverty infiltrates

itself into generations due to its influence on children (Hunt, 1996). Even though the correlation between poverty and Illiteracy has been heavily documented and worked on, the efforts to eliminate illiteracy from millions of people have not been successful (Bedar, 1991).

Oscar Lewis (1966) postulated that the culture of poverty and illiteracy, once started, is likely to continue into generations unless there is outside intervention. Kofi Annan, the former Secretary-General of the United Nations, once said.

> Literacy is a bridge from misery to hope. It is a tool for daily life in modern society. Especially for girls and women, it is an agent of family health and nutrition. For everyone, everywhere, literacy is, along with education in general, a basic human right. It is a bulwark against poverty and a building block of development. (Annan, 1997)

According to UNICEF, "Children and youth living in rural areas have little access to education or skills training programs, and overall, the quality of education in rural areas is generally low due to poverty and limited investment resources." (Rolz, 2016, para 2).

A surface-level structural analysis of world illiteracy indicates that the "problem" is known, i.e., the illiteracy; the "need" is to educate the masses, and the "solution" is to take all possible measures to educate them (Kenny & O'Donnell, 2015). This situation is more complex than it looks, the problem is not that straightforward, and the solution is not that effortless.

Despite global efforts, the progress in eradicating illiteracy is not as vigorous as it should be. According to UNESCO (Just Actions, 2021), the goal to educate the illiteracy hotspots located in Sub-Saharan Africa, South Asia, and Latin America has fallen by 26% since 2000 against the 50% target. Among 775 million global illiterates, 70% are females (The World Bank, 2021). On the other hand, focusing on the global adult literacy rate (15 years and older), there has been a 20% increase, from 67% to 87% in the last four decades (Statistica, 2021). Unfortunately, the COVID-19 had the largest impact on the children and youth. The 2020 UNESCO report on COVID's impact revealed that there were 1.52 billion children out of school,

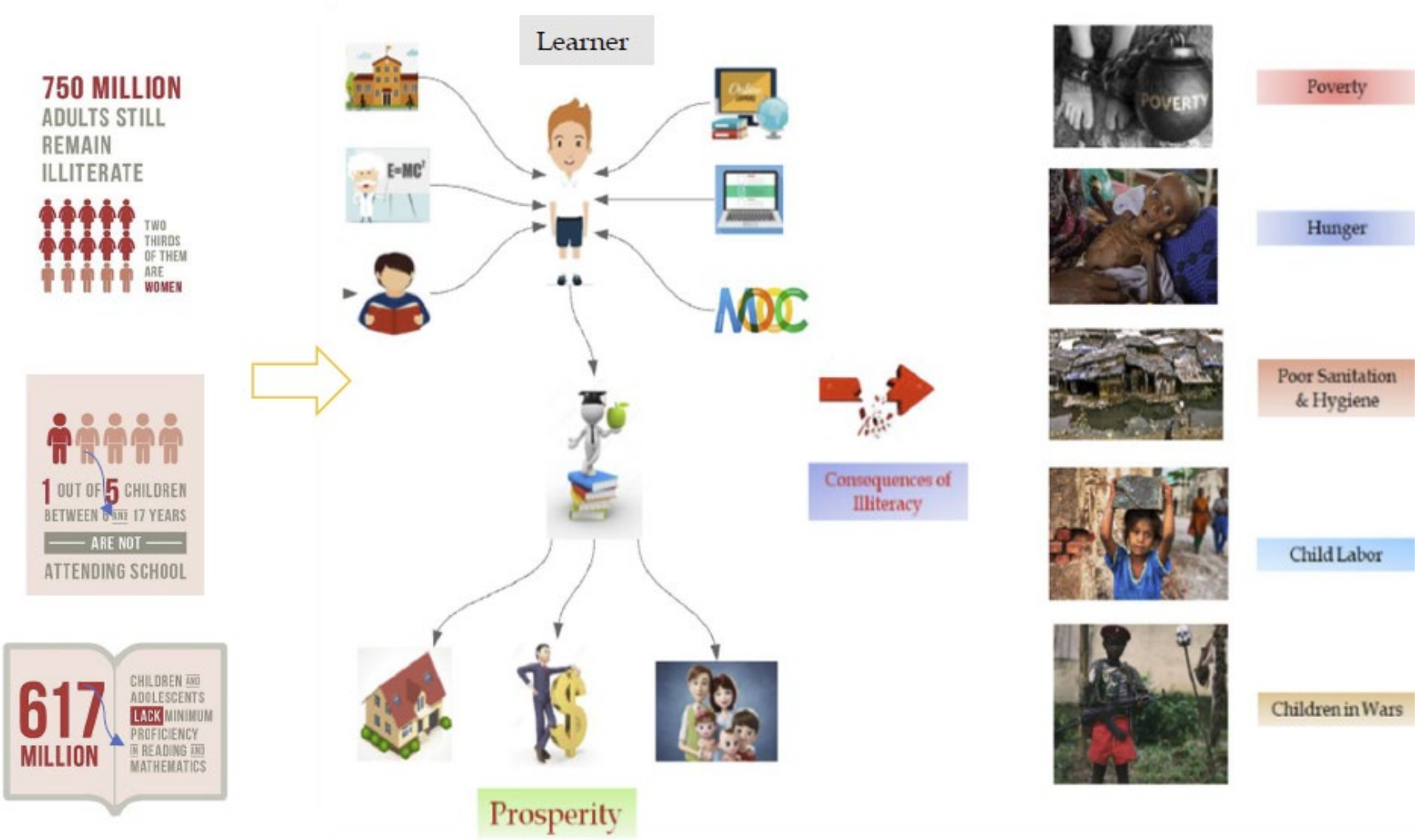
with millions that may never return to school due to consequential poverty. The paper focuses on finding ways and measures to educate this vulnerable population (school-age children) of the world.

The deep-seated illiteracy situation may be compared with the term VUCA, introduced by the US military when faced with extreme conditions at two war fronts in Iraq and Afghanistan (Source). The VUCA conditions (Volatile, Uncertain, Complex, and Ambiguous) are the best fit to invoke "Learning Agility." Learning agility is a human characteristic of knowing what to do when one does not know what to do in a drastic situation (Jha, n.d.). Learning agility, in this case, involves constantly thriving in developing methodology in educating the masses. Educating more than three-quarters of a billion people is an overwhelming task (Fiske & Ladd, 2011). The ability to learn and change this problematic situation may involve a Soft System Approach /Methodology (Checkland and Poulter, 2007).

This paper aims to develop a soft systems methodology and apply this approach to propose an effective and proficient education system for school children. Instead of only recommending a solution using structured system analysis or a hard system approach (E Pluribus Unum – out of many, one), the paper employs SSM to learn and appreciate the complicated situation. It determines that the complex situation is problematic, expresses the problem situation with historical and real-world conditions, uses rich picture analogy to derive root definitions of relevant systems, and provides a framework for tackling the situations with a consensus with all stakeholders. Input-output transformation systemigram or Lucidchart "Rich-Picture" diagrams define the problem and propose a possible solution (Figure 1.2).

Figure 1.2

Problematic Situation Defined –SSM Approach (Rich-Picture Diagram)



The Root Definitions

As per Checkland's methodology, to approach an SSM in a problematic situation, a naming convention, CATWOE, is applied to the system of interest. This naming process is known as the SOI's root definition that helps us understand its functions and purpose. This precise naming or root definition is a structured description and is beneficial when applied to various system components.

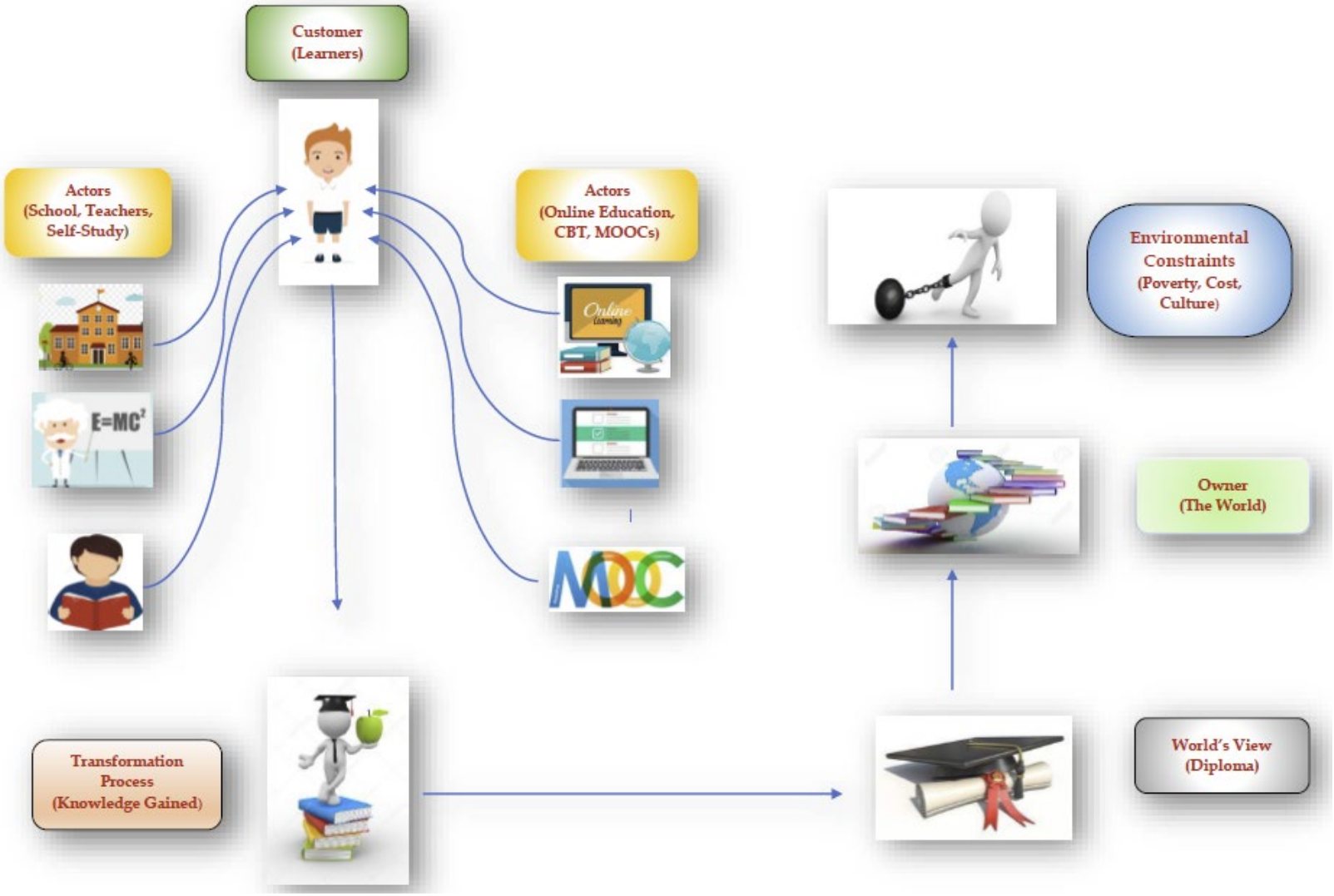
The CATWOE Analysis: A Root Definition of a System

The CATWOE analysis is used to identify and solve system problems that often involve multiple and conflicting interests. It was developed by David Smyth, a member of Peter Checkland's team. CATWOE is an acronym that stands for customers – actors – transformation process – world view – owners – environmental constraints. So in the case of this SOI, the CATWOE of real-world would be:

- C Customers: users of the system: students / learners
- A Actors: schools, teachers, self-leaners, online education, CBT, MOOCs
- T Transformation process: Institution education is transformed into literate students with HS-diploma
- W World View: Graduation (the Diploma). Evidence that the graduate possesses a standard proficiency and skills in the domain of qualification.
- O Owners: the educated world
- E Environmental Constraints: Cost of providing quality education, poorly implemented educational programs, inadequate educators, lack of interest, poverty, child labor, and cultural restrictions.

Figure 1.3

Real–World Root Definition (CATWOE Analysis) Rich Picture Diagram



Real-World Attempt to Tackle the Problem

Around one in five people are completely illiterate, and over three billion people worldwide struggle with basic level reading and writing (World Literacy Foundation [WLF], 2018). Simultaneously, the segregation theory of socialization (Lewis, 1959) hypothesizes that the poor segregate themselves from mainstream society and form a nation. Education offers the only route out of poverty for promising economic conditions, but this requires a dedicated and special intervention by the privileged (AIR, 2018). So far, educational organizations like UNESCO, UNICEF, The World Bank, United States Agency for International Development have been able to reach a huge illiterate population, but millions are still deprived.

In the 2017 report on "Reimagining the Role of Technology in Education," the United States Department of Education states that technology could be used in transforming education and hence learning. Technology is transforming education, changing how, when and where students learn, and empowering them at every stage of their journey (Intel, n.d. para 1). The advent of personal computers also was a big leap in delivering education to the masses. The introduction of radio and television educational broadcasting in the 1960s set the groundwork for educational technology programs in Africa. Unfortunately, the Africa Information Society Initiative failed to deliver its promise to connect African distant schools via computer (TechAide, 2020). Proponents of technology in education cite that technology develops digital citizenship in students (Marico, 2017) and makes students more responsible. Tylor Wantulok (2015) argues that technology can enhance relationships between teachers and students.

Effective use of information and communication technology (ICT) also has shown positive results in educating the masses. The French Development Agency (AFD), the Agence Universitaire de la Francophonie (AUF), and UNESCO conducted a feasibility study on ICT use

in education. It was found that ICT while using mobile learning, offers several benefits to the learners (How digital technology can help, 2017). Mobile teaching offers low-cost learning resources, which is an added value compared to traditional forms of teaching and supplements to teachers' training.

With the massive installation of cellular towers, mobile communication in African countries has surpassed entire South America. More than 789 million people use mobile phones, making it the second-most populous continent after Asia with mobile phones (Fogarty, 2018). In 2011, the United Nations Education, Scientific & Cultural Organization (UNESCO) collaborated with Nokia to identify and develop educational applications on mobile devices to the distant population. At the same time, educators benefit from using mobile devices to get updated knowledge and pass it to their students. Cyber education programs are also reaching hundreds of thousands via telephones in Malawi, Senegal, and others. Studies have shown that the use of technology in spreading education has a significant improvement in the literacy rate in Sub-Saharan Africa (Barouni & Broacke, 2014).

Mass communication technology has been used as a principal driver of education in Africa since the 1960s. As early as 1963, countries like Ivory Coast, Niger, and Senegal developed key programs using radio and television to encourage elementary education, advanced teacher training, and direct teaching. But the integration of ICT has multiplied these efforts exponentially in the continent. With the shift from traditional content-based education, mobile technology offers to replace the deficiency of textbooks and other reference material. The distribution of 600,000 plus Kindle-style readers in nine African countries significantly impacted their students and led to impressive scores on standardized tests (Source). In addition, implementing massive open online courses (MOOC) through mobile devices has reached

hundreds of thousands of students on the continent. Despite these substantial efforts, proper standardized education has not reached all people yet, especially most of the rural population is still deprived of basic education. Even with the opening of numerous education centers in sub-Saharan Africa, millions of school-age children do not have access to proper education or education not available to them at all.

So, what is the best possible way to reach those underprivileged children, and how could the masses be educated in shorter than centuries. In the 2017 report on "Reimagining the Role of Technology in Education," the United States Department of Education stated that Technology could be used in transforming education and hence learning. It incorporates innovative measures to deliver knowledge and builds unique relationships between students and educators (DOE, 2017). Students get motivated by these modern methods and easily adopt new learning experiences.

The Current Efforts

One of the advantages of technology in education is that it has democratized the education available to everyone. Open educational resources (OER), zero textbook cost (ZTC) materials, and massive open online courses (MOOCs) are the evolving types of teaching and learning materials available to the students. Considering MOOCs as one of the pioneer educational technologies, its material supports the 2015 "Every Student Succeeds Act" by providing mostly free relevant course material to all (Source). The higher cost of education has always been a stressor for most students. The College Board reported that an average student spends $1,440/year on college textbooks (Rafferty, 2019). The argument that textbooks offer superior course content was contradicted by a study at Virginia State University that MOOCs showed increased student engagement and learning, as it had no burden on students' pockets

(Feldstein et al., 2012). In today's world, with more than one billion students heading to schools every day (UNICEF, 2020), 617 million of them cannot reach minimum proficiency levels in comprehension and math. Inadequate educational resources are to be blamed. In a typical classroom, the textbook is the bridge between the teacher and the learner. This bridge is broken when students cannot afford expensive books. This gap can be filled with the technology-enabled MOOCs bridge.

A little over a decade ago, MOOC's free courseware revolutionized the delivery of education. In 2008 Stephen Downes and George Siemens developed the first MOOC course on Connectivism and Connectivity, with only 25 students enrolled in their online class. Soon Peter Norvig and Sebastian Trun offered a free "Introduction to Artificial Intelligence" course, which attracted 160,000 students worldwide, and about 20,000 completed the program. Later in 2012, Trun founded a MOOCs platform as Udacity to offer free courses, followed by Coursera by Stanford's professors. However, MIT wasn't left behind and introduced edX in collaboration with Harvard. This partnership added UC Berkley, The University of Texas System, The University of Adelaide, and hundreds of more institutions worldwide. The consortium offers a massive 2900+ courses, with 100+ million enrollments serving 462 institutions in 72 countries worldwide (edX Press, 2020). Coursera mostly focuses on professional and technical training, whereas edX specializes in humanities and natural sciences (Edukatico, 2020). Students can audit the classes for free or get a completion certificate for a fee.

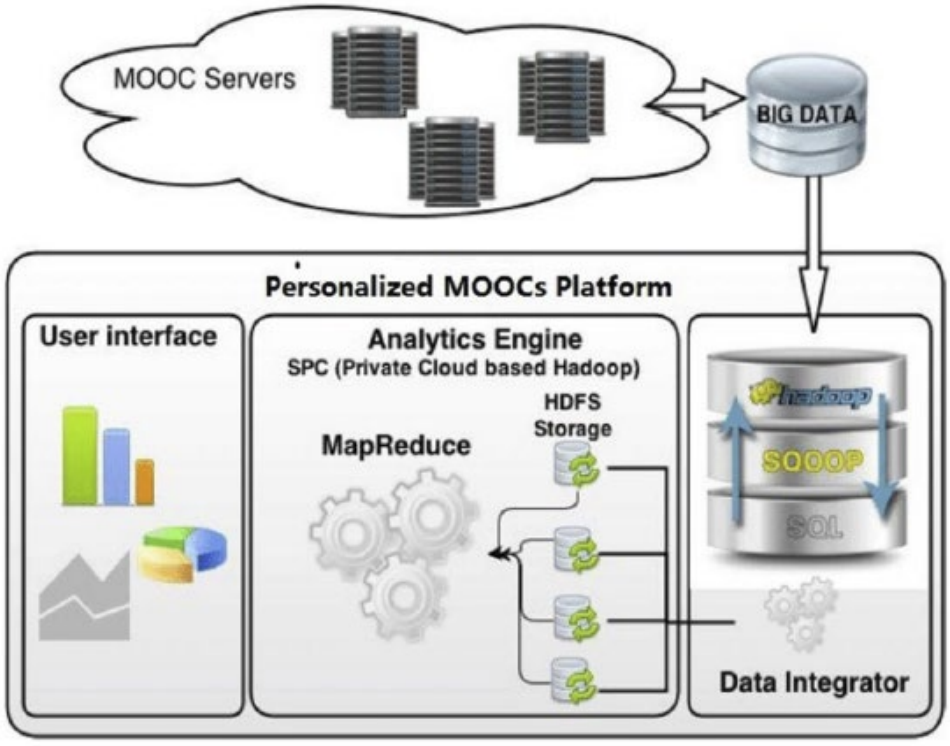
MOOCs are an education movement for hungry learners. It is an identity of a very positive illiteracy elimination venture. It may be termed as a tsunami of educational effort led by educators of the world. MOOCs are collections of learning objects linked to general learning goals (Spector, 2014). Spector (2014) also reported that MOOCs' proper assessment might not

be termed instructional objects due to formative and summative assessments. Competency in learning depends on effective feedback. Timely feedback helps the learner in adjusting learning strategies, bolsters self-confidence; thus, one can progress better in the studies. A mini-MOOC is a shortened version of the full-scale MOOC (Vassiliadis, 2018) targeted to emphasize a specific topic. Subject matter experts are still developing this concept.

Educators have been struggling to provide personalized learning models to all learners. Traditional teaching methods have been outpaced by expanding blended learning environments and the emergence of what has been termed "personalized learning" (Watson, 2008). ''Students should be at the center of learning because there is no other place they could be" (Dowens, 2015). A personalized learning environment highlights student's growth by tailoring learner's interests, strengths, and needs (Patrick, Kennedy, and Powell (2013).

Figure 1.4

Design of a Personalized MOOC Platform

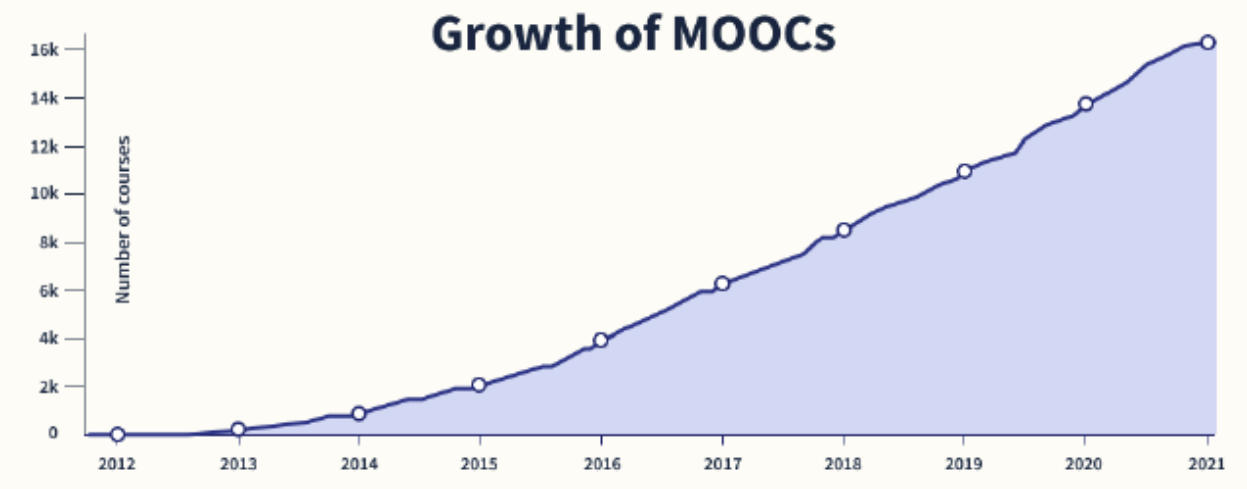


Advancements in MOOCs have further explored online mini-libraries to customize learning contents using artificial intelligence. A predefined MOOC content is personalized for the learner (Hu, Miao, Leung, & White, 2017). An AI-based personalized MOOCs system develops micro-MOOC contents using backward design, in which course objectives and evaluation criteria are determined first before developing the learning contents (Childre, Sands, & Pope, 2009). Short micro-MOOC providers like Curious and Pathwright are appealing to working professionals for their personalized content.

The COVID-19 pandemic saw an overwhelming number of academic institutions closing, leading to hundreds of millions out of school. However, these closures had a very positive impact on MOOC education as it had the highest number of enrollments. In 2020 alone, MOOC registration rose to 180 million. The number includes more than 60 million first-time registrants, equivalent to more than one-third of students ever registered on this platform (Shah, 2020). In addition, some 950 universities offered 16,300 courses, 360 micro-credentials, leading to 19 MOOC-based degrees (The Report by Class Central, 2020).

Figure 1.5

Growth of MOOCs



The MOOC-based degrees are not cheap, and the tuition may be up to $44,520 (Ledwon, 2021) for the University of Michigan's Master of Public Health program. In addition, the fee for a high school credit could range from $150 to $350 for Texas Tech University high school courses (Moon, 2019).

For school children, MOOCs offer a great resource for concept building. From algebra to physics, language arts to accounting, economics, and world geography, there are more than 4,000 courses to take for free. Khan Academy, Coursera, and edX are a few of the many course providers.

Analyzing MOOCs as a Contender for K-12 Education

MOOCs could be a viable solution to eradicate illiteracy among millions of children of the world. This is because its vast array of free and easy access to thousands of courses in almost all subjects can reach the target population. But it does have quite a few significant limitations. Let us review them one at a time:

- Not structured: Unlike higher degree-granting (Bachelor/Masters) institutions, none of the providers have utilized MOOC content as a structured institution. There are no MOOC-based K-12 schools available for free. Hence students are unable to get a high school diploma and progress forward to higher education.
- Not standardized: A diploma-granting institution requires state and governmental certification to award high-school completion certificates. The accreditation guidelines ensure that the institution meets minimum governmental education standards for providing quality education. There are no free accredited MOOC-based schools available, and there are no governmental accreditation standards for certifying such institutions.
- No credit-earning standards. Reward and punishment act as the guiding principles of human behavior. In the absence of a completion diploma/certificate, MOOC-based education could only be used as a supplementary education.
- No personalization: There is no personalized MOOC available for K-12 students. Mini/micro-MOOCs are targeting only adults and professionals

- No standardized assessment: There are no periodic assessment standards available for MOOCs to evaluate the mastery of the subjects. Only a completion certificate could be granted, which is not sufficient for a high school diploma.

- No feedback: Feedback keeps students adjusting their learning strategies, boosts self-confidence, and motivates learning. MOOCs lack this great feature of educational mindset.

- No engagement: The impersonal nature of MOOCs does not offer a student any engagement strategy to the course.

- No progress checks: Keeping students on track is not available on this one-way delivery of lessons.

- Very low completion rate: An MIT study (MIT Pivot, 2019) shows a 3.13 completion rate among MOOC students (Reich & Ruipérez-Valiente, 2019). A deterrent to students.

- There are some accredited online K-12 schools. These structured institutions award diplomas and completion certificates. Unfortunately, these are expensive, with tuition exceeding $8,000, which is not affordable for the target population.

The SSM evaluation leads to a conceptual alternative, discussed below:

Figure 1.6

SSM - Conceptual Model Proposition

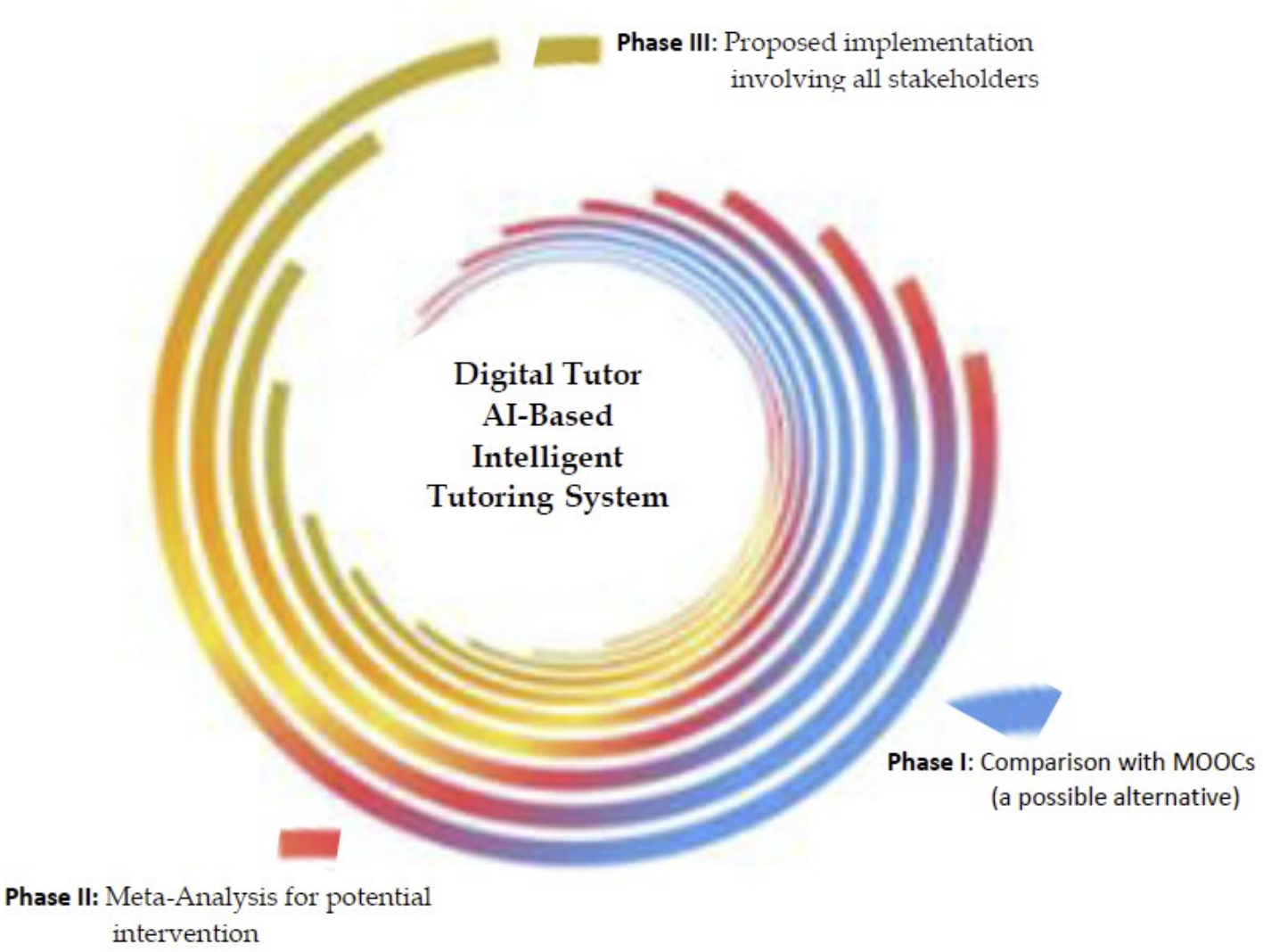


Figure 1.7

Conceptual Model of the System Named in the Root Definitions

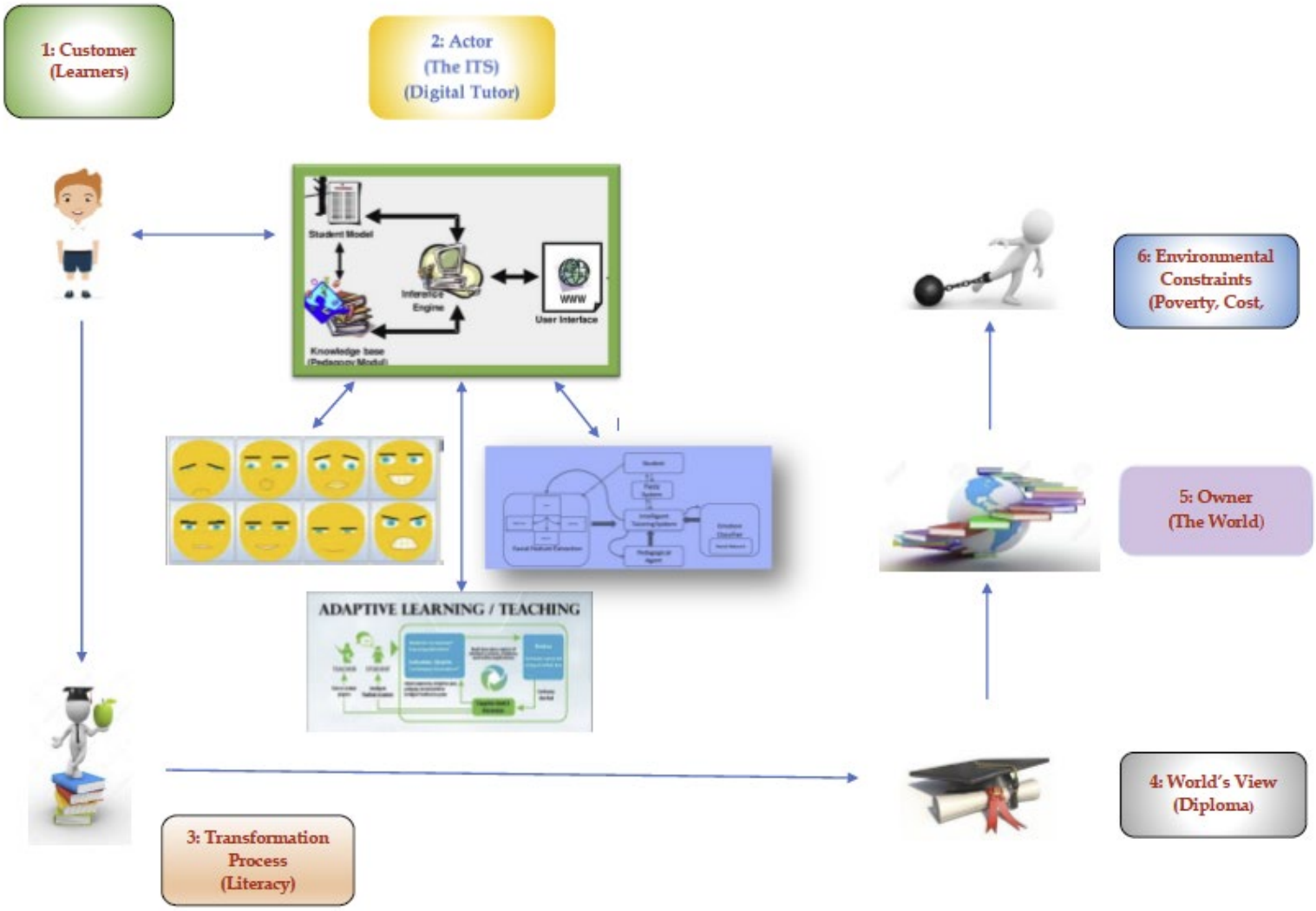
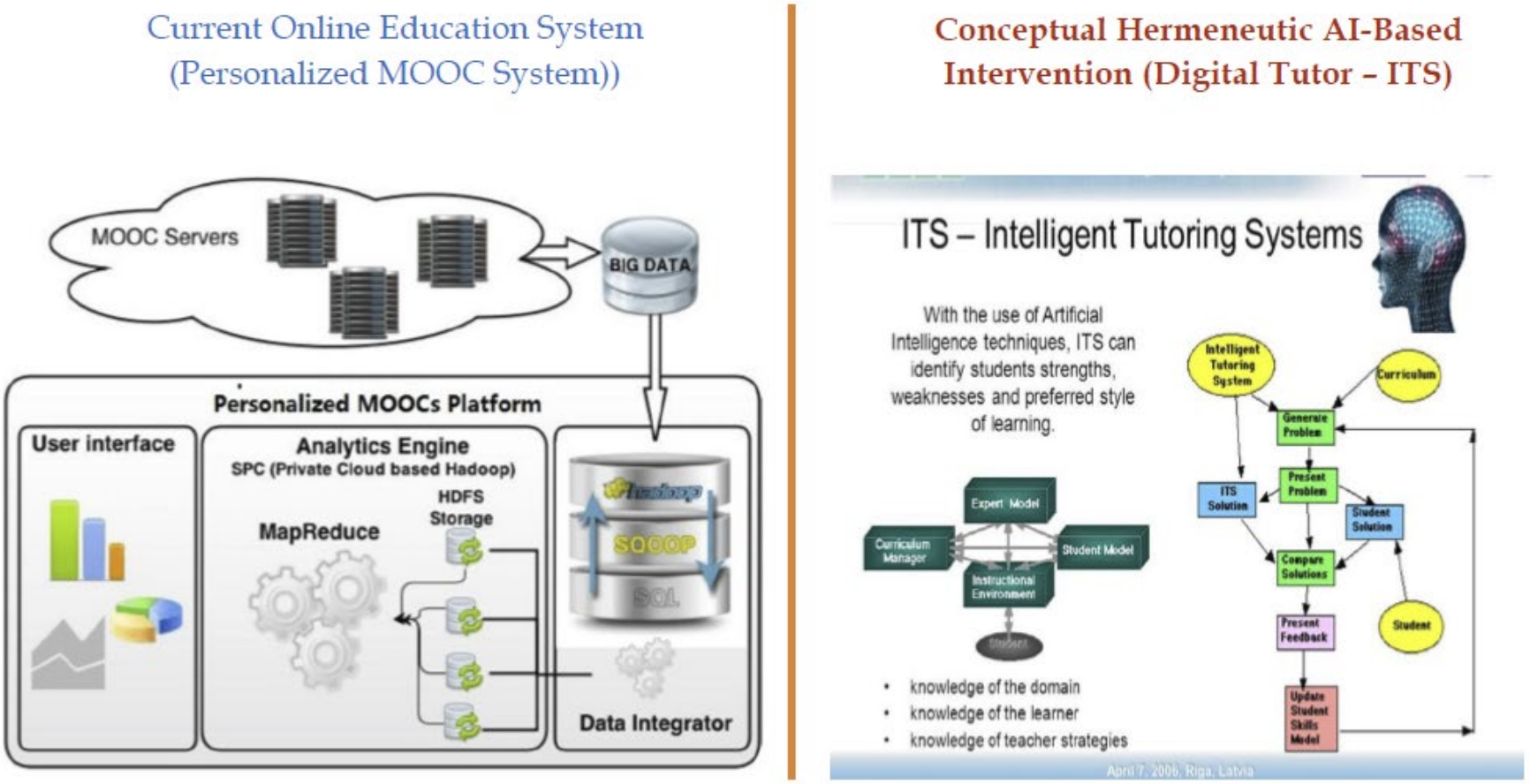


Figure 1.8

Comparison of Real-World Model with Conceptional Model (MOOCs vs. Digital Tutor)



The Conceptual Model and Its Comparison to the Real-World Model

The real-world model discusses those educational technologies, like mobile learning, MOOCs, and others, are great tools in teaching and learning. But these methods have not been fully integrated into distant regions of the world, and millions are still deprived of quality education. For example, the mobile industry in Africa already accounted for 8.6% of Africa's GDP in 2018, and its internet use accounts for 12% of the world (Creswell, 2020). To educate millions of students, a more robust and effective education system would be needed. This system should provide structured quality teaching and reward students with educational diplomas acceptable by higher educational institutions. Unfortunately, MOOCs or other technological approaches do not offer such diplomas as yet.

The SSM analysis leads us to an AI-based educational technology to address this problematic situation, the Intelligent Tutoring System. The ITS is a product of six universities' research and development known as the Byzantium project. The ITS is a general-purpose tutoring system builder, and many institutions have positive feedback while using them. (Kinshuk, 1996). Thus, an "Intelligent Tutoring System" (ITS) could offer the "Magic Wand" for eradicating Illiteracy from the world (Gharehchopogh & Khalifelu, 2011).

These AI-based educational instructional systems provide customized instructions and immediate feedback to the students (Psotka, Massey, & Mutter, 1988). ITS tailors the instructional content framework and teaching strategies after evaluating students' pre-existing knowledge, learning habits, & styles (Wenger & Ohlson 1987). These systems dynamically adapt the content or style of instruction by making inferences about a student's mastery of topics or tasks (Murray, 1999). These computer programs incorporate modalities of artificial intelligence to provide a symbolic tutor that identifies both content and teaching methodologies

(Nwana, 1990). Research finds that an ITS could be a good replacement for one-on-one adaptive tutoring (Sparks, 2019).

Some of the ITS Features

- These are significantly helpful in providing instructions and feedback to learners in a customized manner that typically requires minimal human intervention.
- AI-based systems do not require human intervention (A workable replacement for an inadequately qualified teacher or no teacher)
- The instruction has a close association with cognitive learning theories and intelligently customized one-on-one tutoring.
- Designed to give access to quality education to all types of students
- In a typical ITS, pedagogical changes occur internally, based on the input from the user.
- The system gathers information about the user by observing the use of applications, and in particular, by observing the browsing behavior of the user (Phobun & Vicheanpanya, 2010)
- The effect sizes of answer-based computer tutoring (Computer-based tutoring - CBT), the ITS, and a human tutor are compared with no tutoring, show that a Cohen's d = 0.3. d = 0.76, and d=0.79 respectively (VanLEHN, 2011).
- These educational practices demonstrate that the ITS is as significant as a human tutor to deliver knowledge to students.

The forthcoming chapters discuss the features of the ITS in detail.

- Chapter 2: The components of ITS and their functionality
- Chapter 3: Discussion of how the ITS engages students in the lessons
- Chapter 4: A meta-analysis on the effectiveness of an ITS.
- Chapter 5: Discusses the implementation stage of the SSM, environmental constraints and limitations, deployment issues, future trends, further research needed, and possible governmental policy changes needed to adopt this mode of education.

In conclusion, I establish a case for a sweeping intervention to address illiteracy in the world. The incorporation of SSM due to learning agility gives rise to a systematic comparison of real-world educational technologies with a human-like AI-based intelligent tutoring system. The

first paper introduces the ITS, with all of its features to deliver education to the masses. The second paper provides evidence that the ITS can be used as a teaching tool with all the capabilities of a human tutor. It engages the learner in the lesson using emotion and gazes recognition techniques. In zoning out, the DT uses two-way dialog to bring the student back to the learning process. Finally, the third paper discusses the SSM approach briefly while establishing ITS's effectiveness by running a meta-analysis on 52 different studies. The statistical analysis shows an above moderate practical significance of the ITS, thus making it a viable intervention contender in teaching the target population.

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CHAPTER 2

THE DIGITAL TUTOR: A CONCEPT, A PASSION, A REALITY: AN INTELLIGENT SOLUTION TO THE WORLD'S ILLITERACY MENACE*

Abstract

Many world-class universities offer free K-12 online MOOCs, but only a few deserving students benefit from this education platform. Studies show that only 3 to 5% of students enrolled in MOOCs complete their courses. For children with less self-discipline as compared to adults, this success rate could be much lower. Moreover, the MOOCs are not structured coursework that would satisfy high school completion requirements. A possible solution to help eradicate illiteracy may use AI technology in teaching the masses. While applying adaptive learning methodology, a Digital Tutor (DT) uses Lyrebird, an AI digital voice engine. Upon the student's login, the resident Digital Tutor loads the virtual classroom and the lesson on the computer. After teaching the lesson, the DT will assess mastery of the concept. In case of deficiency, it would repeat the lesson, or the student can pause/replay the instruction. The DT uses a cloud-based AI interface with the Lyrebird voice engine to deliver the lesson at the backend. When an internet connection is unavailable, the Digital Tutor steps down to DT-Lite and performs teaching and assessment tasks using lessons stored on the local storage. This innovative teaching methodology is expected to revolutionize education delivery to the underprivileged who do not have access to quality education and is likely an effort to eradicate illiteracy from the world.

Keywords: Cloud-based, intelligent tutoring system, digital tutor, adaptive teaching/learning

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Introduction

The Universal Declaration of Human Rights (UDHR) signatory nations promised to prioritize fundamental human rights to their citizens (UNO, 1948). Among those 30 articles of UDHR, article 26 promises that everyone has a right to education. However, even though the global literacy rate has increased from 42% in 1960 to 86% in 2015 (OECD, 2015), a big percentage of the emerging nations' population is still illiterate even after 71 years of the HDHR signing. Out of 775 million illiterates globally, more than two-thirds of them are females (UNESCO, 2018). Kofi Annan, the former secretary-general of the United Nations, once said.

Literacy is a bridge from misery to hope. It is a tool for daily life in modern society. Especially for girls and women, it is an agent of family health and nutrition. For everyone, everywhere, literacy is, along with education in general, a basic human right. It is a bulwark against poverty and a building block of development. (Annan, 1997). According to UNICEF, "Children and youth living in rural areas have little access to education or skills training programs, and overall the quality of education in rural areas is generally low due to poverty and limited investment resources." (Rolz, 2016, para 2).

A surface-level structural analysis of the world illiteracy indicates that the "problem" is known, i.e., the illiteracy; the "need" is to educate the masses, and the "solution" is to take all possible measures to educate them (Kenny & O'Donnell, 2015). This situation is more complex than it looks, the problem is not that straightforward, and the solution is not that effortless.

One Possible Solution

Education offers the only route out of poverty for promising economic conditions, but this requires a dedicated and special intervention by the privileged (AIR, 2018). Educating more than three-fourths of a billion people is an overwhelming task (Fiske & Ladd, 2011). Despite the

substantial efforts of great world organizations like UNESCO, UNICEF, The Global Partnership for Education, and many others, proper education has not reached all people yet, especially most of the rural population is still deprived of basic education. Even with the opening of numerous education centers in sub-Saharan Africa, millions of school-age children do not have access to proper education or education not available to them at all. So, what is the best possible way to reach those underprivileged, and how could the masses be educated in less than a longer span over centuries? In its 2017 report on "Reimagining the Role of Technology in Education," the United States Department of Education states that technology could be used in transforming education and hence learning. It incorporates innovative measures to deliver knowledge and builds unique relationships between students and educators (DOE, 2017). Students get motivated by these modern methods and easily adopt new learning experiences.

A possible solution would be incorporating Artificial Intelligence (AI) in education for the masses. An "Intelligent Tutoring System" (ITS) could offer the "Magic Wand" for eradicating illiteracy from the world (Gharehchopogh & Khalifelu, 2011). The research analyzes that even though there is an inadequate supply to demand ratio i.e., there are not enough resources available to educate the learning hungry world. Education is not a priority in many cultures, societies, and nations, but we can change this belief (Bernard, 2008). Technology is transforming education, changing how, when and where students learn, and empowering them at every stage of their journey (Intel, n.d. para 1). Research finds that an ITS could be a good replacement for one-on-one adaptive tutoring (Sparks, 2019). Incorporating the digital tutor may offer a better alternative to unskilled teachers or when no teachers are available.

Delivering quality education to the disadvantaged students in rural Sub-Saharan Africa and Asian countries would be possible using a Digital Tutor (DT). The DT is a conceptual model and still under development. It integrates multiple existing and a few underdevelopment

technologies to reach students in distant and remote areas. The technology is not limited to this mode of delivery only and could be used in corporate training, educating special needs students, elderly citizens, and others. Article 26 of the Universal Declaration of Human Rights (UDHR, 1948) promises the right of education for all, but more than 750 million people have been deprived of this basic right (UNESCO, 2018). According to the Brookings Institute (2012) survey, out of 130 million schoolchildren, more than 37 million students are as much educated as their illiterate counterparts. Poverty, child labor, cultural influences, and ill-trained teachers can be blamed for this catastrophe. This paper evaluates the UDHR article-26, the right to education, analyzes its repercussions, and recommends a possible solution to educate the masses.

Brookings Center for Universal Education Educational (BCUE) reports that one in three African children will reach adolescence, lacking even the most basic literacy and numeracy skills (Watkins, 2013). The solution to the problem of illiteracy may lie in using technology, especially utilizing Artificial Intelligence (AI) in teaching the masses. This paper discusses the incorporation of a Digital Tutor (DT) as an alternative to human tutors. The DT utilizes an intelligent tutoring system to offer adaptive learning & teaching (Phobun & Vicheanpanyain, 2010). Compared to no tutoring, the effect sizes of intelligent tutoring systems and adult human tutors are d = 0.76 and 0.79 (VanLehn, 2011).

Main Components of a DT

- The Intelligent Tutoring System
- Adaptive Teaching/Learning
- Emotion Recognition
- Gaze Recognition
- Voice Recognition

- Pedagogical Agent
- Voice Cloning (for teaching)
- Learning Management & Assessment

The DT is a resident program installed on the student's computer. Upon s login, the DT loads the virtual classroom and that day's lesson plan on the computer. After teaching the lesson, the DT assesses the mastery of the concept and challenges the student with higher difficulty problems. In case of any deficiency, it repeats the lesson, or the student can pause/replay the instruction. The DT uses an intelligent tutoring system (ITS) and AI-based pedagogical agent while incorporating adaptive teaching/learning techniques in the backend. When an internet connection is unavailable, the DT performs its tasks using lessons stored on a local storage device. This could be termed as a lighter version of the DT.

Another possible use of a DT would be that it could be used in helping students with special needs, as student-based learning is more effective in those cases. And there is no doubt that technology is helpful in distance learning when reaching an institution is not an option for the student.

Literature Review

The Intelligent Tutoring Systems

The ITSs are AI-based tutoring systems, incorporate computers in tutoring but differ from their computer-based tutoring (CBT) antecedents. Rather than relying on delivering a lesson to a passive learner, the ITS tailors the concepts after evaluating pre-existing knowledge, student's learning styles, and the advancements through the contents. ITSs are computer-based instructional systems that apply frameworks of instructional content and teaching strategies (Wenger 1987, Ohlsson 1987). These computer programs incorporate modalities of artificial

intelligence to provide a symbolic tutor that identifies both content and teaching methodologies (Nwana, 1990). These systems dynamically adapt the content or style of instruction by making inferences about a student's mastery of topics or tasks (Murray, 1999). These are significantly helpful in providing instructions and feedback to learners in a customized manner that typically requires minimal human intervention.

Intelligent Tutoring Systems (ITSs) are computer-based instructional systems that apply frameworks of instructional content and teaching strategies (Wenger & Ohlsson, 1987). These computer programs incorporate modalities of artificial intelligence to provide a symbolic tutor that identifies both content and teaching methodologies (Nwana, 1990). These systems dynamically adapt the content or style of instruction by making inferences about a student's mastery of topics or tasks (Murray, 1999). These are significantly helpful in providing instructions and feedback to learners in a customized manner that typically requires minimal human intervention.

The design of the ITS has a direct influence on the efficacy and impact on the solution. In a typical ITS, pedagogical changes occur internally, based on the input from the user. The system gathers information about the user by observing the use of the application, particularly by observing the user's browsing behavior (Phobun & Vicheanpanya, 2010). The ITS then varies the content presented to the learner based on information stored in the system's learner model. All these changes and modifications happen within the ITS's multiple internal models, briefly described here.:

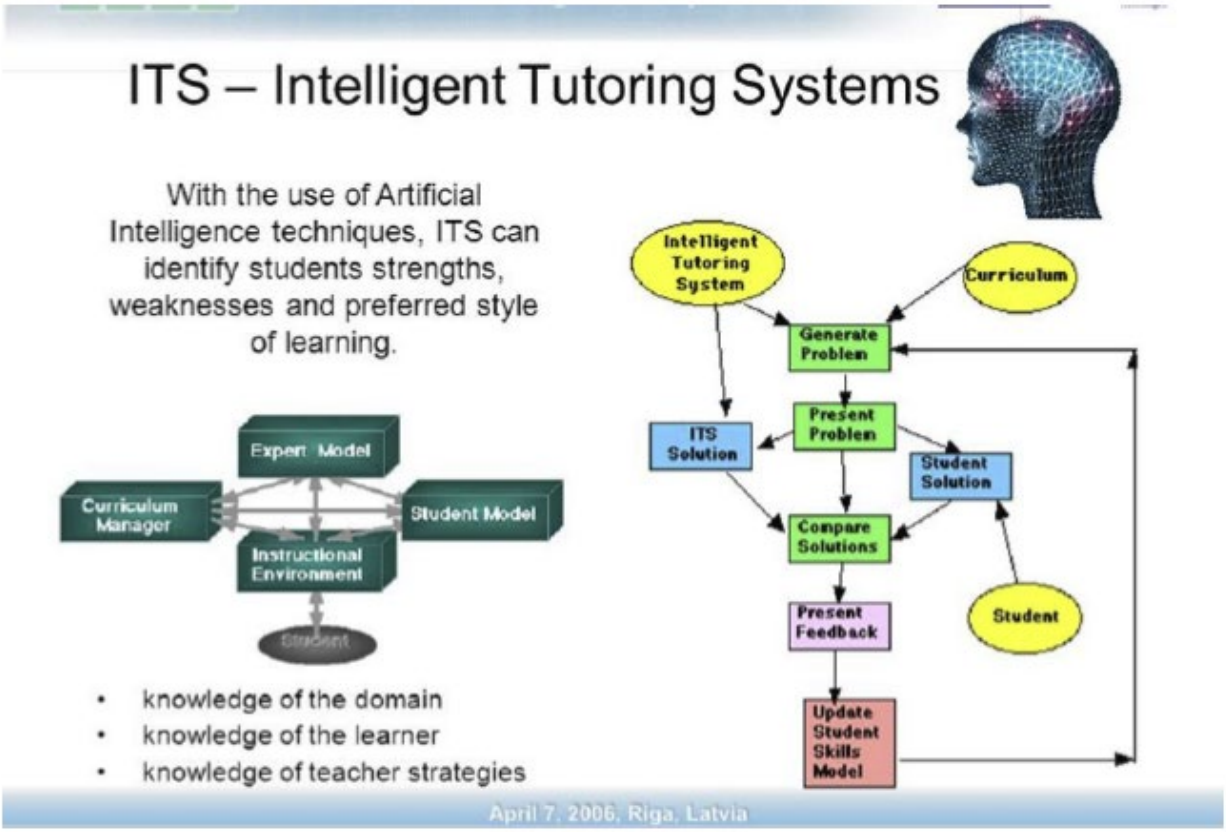
The effect sizes of answer-based computer tutoring (Computer-based tutoring - CBT), an ITS, and a human tutor are compared with no tutoring, show that a d = 0.3. d = 0.76, and d= 0.79 respectively (VanLEHN, 2011). This demonstrates that the ITS is as significant as a human tutor to deliver knowledge.

The Expert/Domain Model

It is the intellectual model or the expert model. This contains a knowledge base that accounts for all the possible steps for the concepts, problems, lessons, reasonings/solutions for problems, teaching methodologies. It also keeps a student's skill profile and interacts with the tutor model to compile the lesson plan. The logs of the student's interaction with the system are maintained to develop strategies for teaching. The student's learning style, prior knowledge on the subject, behavior patterns all help the Domain Model in developing a profile; "It can fulfill several roles; a source of expert knowledge, a standard for evaluating the student's performance or for detecting errors, etc." (Nkambou et al., 2010, p. 4).

Figure 2.1

The Components of an ITS



The Student Model

The student model collects information about student's learning progress. It also develops and maintains a profile of the learner, including his previous knowledge of the subject. A chosen set of attributes or characteristics related to the learning process is analyzed, stored, and shared with the Domain and the Tutor models by defining relationships among skills, subskills, and prerequisite skills. The main task of the Student Model in an ITS is to develop a personalized adaptive lesson plan based on his profiles as developed earlier. This model helps the Domain Model in decision making while delivering the lesson to the student.

The Tutoring Model

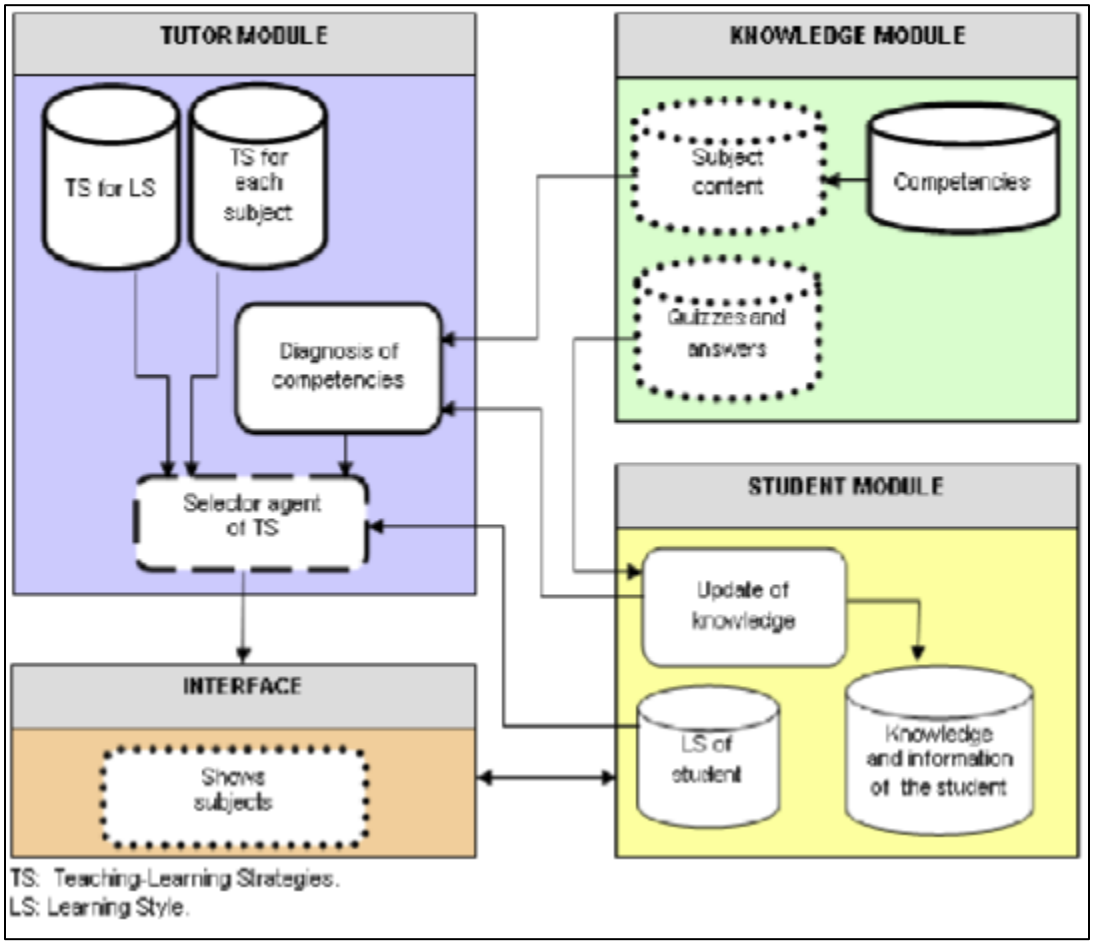
The tutor model receives student data from the Domain and student models and develops tutoring plans and modes of action to deliver lessons. The algorithm helps it to make the right choices in delivering the lesson to the student. It makes these decisions based on student logs, built by the learner's cognitive responses to the lesson. If the case any deficiency, the tutor model revises the lesson with different strategies and examples, just like a human tutor. The progressive feedback to the students helps them to reach proficiency with the predetermined standards.

The Interface Model

For a general student, mostly not very technical, the graphical interface is the ITS. While providing the learning environment, it acts as a digital pedagogical agent that delivers the contents to the learner. The user interface integrates three types of information that are needed in carrying out a dialogue: knowledge about patterns of interpretation (to understand a speaker) and action (to generate utterances) within dialogues; domain knowledge needed for communicating content; and knowledge needed for communicating intent" (Padayachee, 2002).

Figure 2.2

The Architecture of an ITS

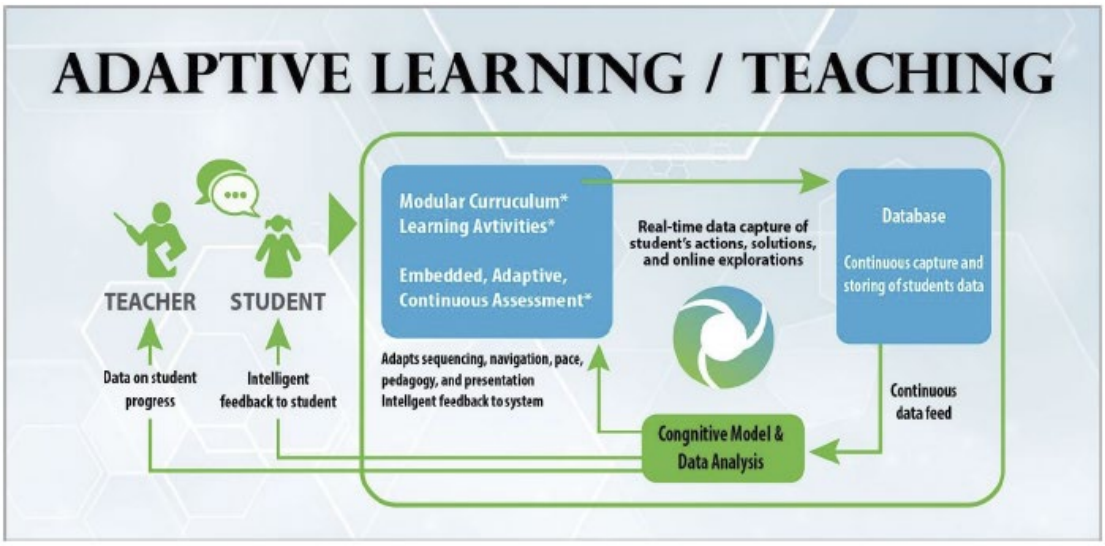


Adaptive Learning /Teaching

The DT will use adaptive learning/teaching methodology to power the learning mechanism. The DT will also collaborate with the Domain Model of the ITS to customize lesson plans based on the student's unique needs and learning skills. The algorithm considers all the log files created by the Student Model, stored in the Domain, goes through the knowledge base that contains the syllabus and if-then-else strategies, and delivers the lesson to the students (Ong & Ramachandran, 2008).

Figure 2.3

Adaptive Learning & Teaching



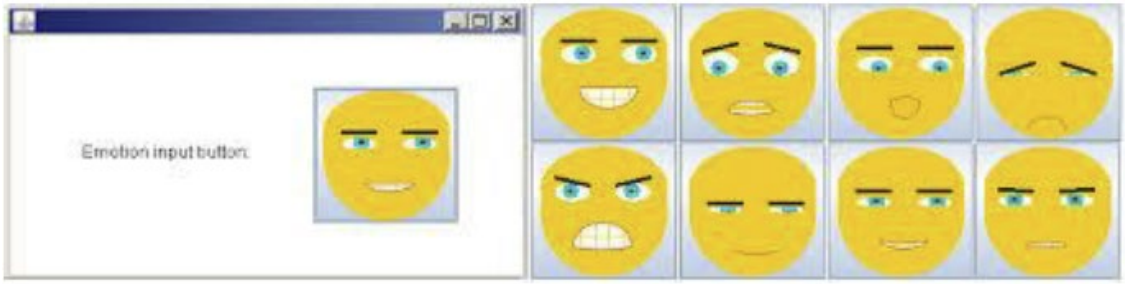
Emotions Recognition

In a learning environment, emotions play an important role in the learning activity. If a learner is not in a state of learning due to fear, frustration, anxiety, and depression can lead to boredom and non-clarity of the concept. The DT uses previous and current log files and the self-assessment AffectButton Tool to measure the student's state of emotion. The AffectButton is a self-report tool that enables users to report their emotions, mood, or attitude about things. It is a simple interactive button that presents a dynamically changing facial expression. (Broekens, 2014)

Behavior patterns like "Pleasure" (pleasant feelings towards lesson), "Arousal" (energy level of the learner), and "Dominance" (ability to cope with the new concept), are measured by the AffectButton Tool using the computer's built-in webcam (Brookens, n.d.). The DT algorithm compares the learning effect size and recorded emotion recognition log files to the Domain Model, which delivers a tweaked lesson and enhanced learning.

Figure 2.4

The AffectButton Tool

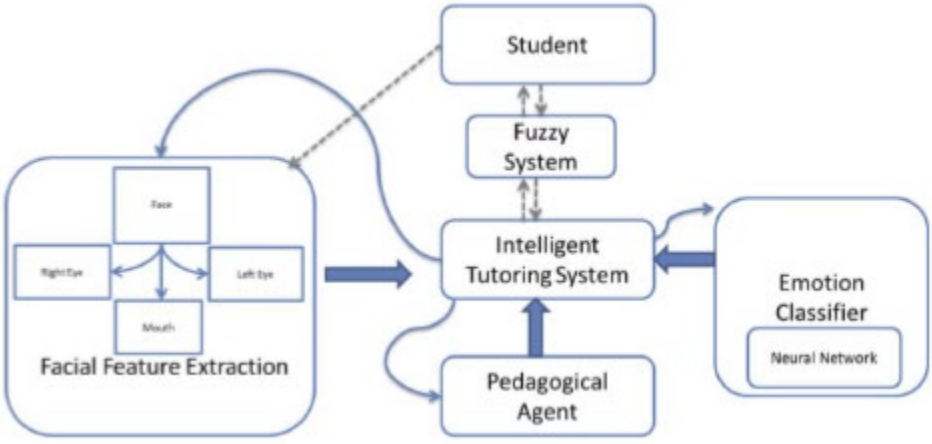


Gaze Recognition

The DT monitors student's boredom, disengagement, or zoning out from the lesson using commercially available eye trackers. The motion of the eye based on the point of gaze is tracked by hardware or software (GazePoint, iMotion, Tobii). In case of any disengagement is found, the DT re-engages the student with a dialog. This technique promotes motivation and, hence learning occurs (D'Mello, Olney, Williams &_Hays, 2012)

Figure 2.5

Emotion Recognition in ITS by Gaze Recognition



Pedagogical Agent / Voice Recognition and Cloning

The DT acts as a pedagogical agent to interact with the student and ITS. Mabanza & de-

Wet (2014) defined it as a virtual teacher that socially engages and interacts with the student in a human style. To interact and communicate, it uses a voice engine to generate a conversation with the learner. Text to Speech (TTS) and Speech to Text (STT) systems like PDF readers, audiobooks, and others have been in existence for a while. The output voice is predetermined in all of these applications and is usually a low-quality computer-generated synthesized robotic voice. The DT will combine a new generation of ultra-realistic voice cloning tools developed by Lyrebird Technologies (Lyrebird.ai) in its TTS application.

Implementation of voice cloning would make an ideal addition to the DT. A human-like pedagogical agent as the user interface would complement benefits to the student (Baylor & Kim, n.d.). Motivating students who have been deprived of education for a long time could prove to be an uphill battle. The assimilation of a national hero as the digital tutor would motivate the students and promote a desire to learn. Using their beloved leader's voice would also inspire their learning and achievement since motivation directs behavior towards goals (Ormond, 2014). A good example would be mimicking the voice of famous African leader Nelson Mandela for African students.

The Technology Behind the Technology

How does this voice cloning technology work? Probably the same way we do as humans. The brain receives inputs in verbal cues in variations of words, pitch, and tempo of the pronunciations, absorbs, processes, filters, creates phonemes, and outputs them into a speech. So is the case with the voice mimicking engine. It receives inputs, analyzes them, filters, and digitizes for a vocal output. A brief description may explain the technology behind the cloning of a voice.

Let's review the working of the Lyrebird.ai by taking the example of D. Vraghavan's (2018) work on deep neural networks for cloning human voice. First, using an input sample sentence; Have a good day. This sentence can be broken down into four steps by the voice engine of the Lyrebird:

1. Converting Graphemes (Text) into Phonemes (Phonetic):

English language, with all the grandeur, is a very difficult language. Words like "Do", "To", "So", Go", may spell in a similar pattern but sound quite differently. At the same time, the words like "Wait, Gate, Eight", totally spelled differently but sound alike. In the Deep Voice engine, the first layer input of the words uses CMU (Carnegie Mellon University) pronunciation dictionary to process the corresponding Phonemes in the TTS pipeline, e.g.:

Wait – W EYI T, Gate – G EYI T, Eight – EYI T, etc.

"Have a good day" would be somewhat: HH AE1 V . AH0 . G UHI D . D EYI .

2. Duration of Phonemes:

The word "unequal" and "fun," the phoneme for the letter "u" is said for a fractionally longer time in the case of "unequal" compared to it in the word fun. When processed, the duration of the word "Have" looks somewhat like this:

[HH (0.1s), AE1 (0.05s), V (0.05s), AH0 (0.05s), …]

3. Fundamental Frequency (F0) Prediction:

Using the computerized spectrometer application, the fundamental frequency of a phoneme is preserved in the TTS pipeline. It would look somewhat like

[HH (180Hz), AE1 (184Hz), V (182Hz), ….]

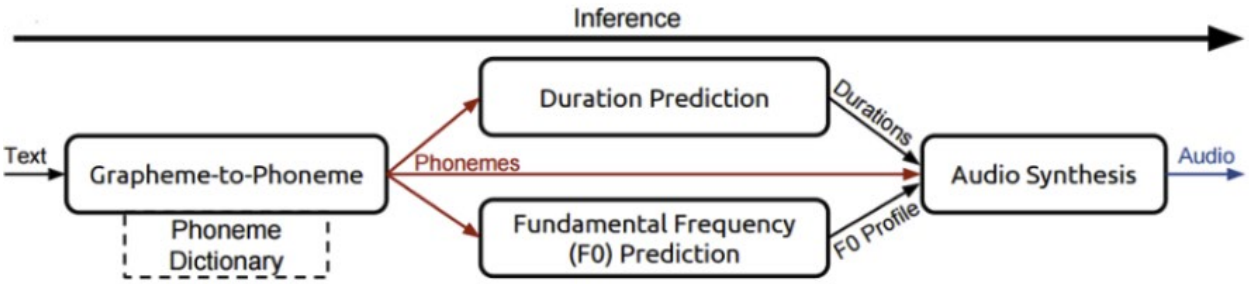
4. Audio Synthesis:

The phonemes of the word's grapheme, the duration of phonemes, and the frequency

prediction (F0) are used to generate an output voice. Since each of us has a unique pronunciation frequency, the voice engine learns it and reproduces it in seconds.

Figure 2.6

The STT / TTS Interface



Voice Cloning

A sample of Lyrebird voice cloning is enclosed herewith for review: Please click the play button to hear politicians discussing Lyrebird.ai.

Figure 2.7

Politicians Discussing about Lyrebird.ai

Conceptual Model of Digital Tutor Front End

The DT functions as follows:

- Digital Tutor: is a resident program in a laptop or chrome-book computer

- Students logs in – DT loads up
- Virtual classroom displayed on the screen.
- DT - Checks the date and loads that day's lesson based on the data fed by the Tutor Model of ITS.
- The syllabus is already developed as per Governmental Education Standards.
- The pedagogical agent teaches the lesson by incorporating cloned digitized voices, animation, slideshows, videos, and other multimedia.
- Assessment is carried out during and after the lesson to check the concept mastery (
- In the case of mastery, the difficulty level could be raised to challenge the student
- If any deficiency is found, DT repeats the concept with different examples and checks if the understanding of the lesson is accomplished.
- The student can pause, replay and or advance the lesson.
- DT uses the Lyrebird Technology Voice Engine to teach.

If the Internet is not available

- DT is a resident program on the computer.
- The syllabus is prepared in advance and installed in the computer storage or USB drive.
- Tests and assessments are recorded, saved in a protected location on the drive, and uploaded manually to the education server.

Discussion

Educators and policymakers cannot deny the influence of this novel teaching methodology, its interactive knowledge delivery, and its role as a teacher, facilitator, and mentor in education. The ITS may not have been adopted fully by the education community in the advanced world (Ferster, 2017), but it can prove very effective in the developing world (Nye, 2015). Enhanced learning occurs through collaborative communication, discovery-based research, and students' motivation throughout the lesson (Eskadari & Soleimani, 2016). The use

of symbolic tutors allows for adaptation to assist students in developing mastery of tasks and topics. This approach to personalized learning provides benefits to students using learner models contained within the system.

The Ethics Behind the Technology

The ethical aspects of misusing these tools will always be there; new rules and regulations must be implemented. Policymakers are aware of the AI integration in our lives, but they must be more vigilant in placing laws to stop its improper use (Scharre & Horowitz, 2018). At the same time, companies are working diligently to develop a multi-factor solution for advanced voice authentication. Passport by Pindrop, a cyber-security developer, is working on the Deep Voice engine to passively identify the authenticity of callers based on their device, behavior, and various voice factors. Pindrop's Deep Voice biometric engine – a system that accesses top-of-the-line neural network technology for speaker recognition to help companies separate suspected fraudsters from authentic callers solely by analyzing voice patterns (Balasubramaniyan, 2018).

Lyrebird.ai Disclaimer

Lyrebird.ai addressed the issue of unauthorized use of voice cloning by posting a disclaimer:

> As pioneers of this technology, we believe that we have the responsibility of guiding its path to developers and the general public. We have worked hard to create principles that accurately reflect the values we espouse as technologists. We have sought the insights of machine learning researchers, our investors, ethics professors, and many others.
>
> Imagine that we had decided not to release this technology at all. Others would develop it, and who knows if their intentions would be as sincere as ours: they could, for example, only sell the technology to a specific company or an ill-intentioned organization. By contrast, we are making the technology available to anyone and introducing it incrementally so that society can adapt to it and leverage its positive

aspects for a good while preventing potentially negative applications. (Lyrebird.ai, 2019, p.1).

Conclusion

The problem of illiteracy has plagued the world's poorest nation like an epidemic. Multiple efforts by different organizations had derived mixed results, but the delinquency in this basic human right is far from a viable solution. Political, financial, and environmental restrictions bar human efforts to eradicate illiteracy from the world. The digital tutor may offer a possible solution for educating the masses. Moreover, in a traditional educational setting, providing a tutor for each student may be ideal, but certainly is not reasonable in financial and other circumstantial constraints. An ITS can provide students with experiences similar to those provided by a tutor but at a fraction of the cost. The world would have to rise with its might, help the poor and work diligently to eradicate illiteracy from the world.

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CHAPTER 3

THE DIGITAL TUTOR AND STUDENT ENGAGEMENT TECHNIQUES:AN INTELLIGENT WAY TO ENGAGE STUDENTS IN ITS*

Abstract

Research has demonstrated that the connection between engagement and success is very critical in a learning environment. Engaging students in the learning process enhances their attention, heightens their focus, stimulates their higher critical thinking skills, and bolsters meaningful learning. At the same time, emotions play an essential role in the learning activity. If a learner is not in a state of learning due to fear, frustration, anxiety, or depression, it can lead to boredom and non-clarity. The intelligent tutoring system (ITS) is designed to simulate a human tutor in a student-centered adaptive teaching and learning environment. It incorporates artificial intelligence by invoking deep machine learning and neural networks to deliver a customized lesson to the learner. The ITS registers students' prior knowledge of the subject, learning habits, and styles in its log files and develops strategies for teaching and engaging students while delivering the lesson. It also keeps track of the student's gaze patterns on the computer screen. In case of student's boredom, disengagement, or zoning out, the Digital Tutor (DT), a virtual pedagogical agent of the ITS, engages the learner using two-way dialogs. This paper discusses the Digital Tutor's design challenges due to student disengagement and strategies to re-engage the learners using gaze patterns, emotion recognition, voice recognition, and two-way dialogs using voice cloning.

Keywords: Intelligent tutoring system, digital tutor, student engagement, gaze/emotion recognition, voice cloning

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Introduction

Learning effectively, processing the text, understanding it, and proficiently integrating it with previously acquired skills are critical for any student. A primary design goal for educators is to have a learning environment where students may adapt to any stressful learning situation by enduring and experiencing lessons modified to their learning habits, styles, and capabilities. Implementing adaptive teaching/learning techniques and intelligent learning design with the help of specific teaching devices and technological instruments can help individuals' particular learning needs.

With the ever-growing diverse student population in today's schools, it is becoming quite challenging for educators to develop foundational and mastery skills efficiently in their students. One solution to this problem is to teach comprehension skills in smaller groups to allow for more individualized attention and specific focus on individual requirements. This practice would help identify individual students' needs and effectively leverage a flexible learning environment to adjust the learning environment experience. This, in turn, would enhance the student's learning experience and result in better attainment of concepts. Reducing classroom populations to have a small class size is not an option in all situations; however, an intelligent tutoring system (ITS) coupled with an adaptive learning environment may offer an alternative solution.

The purpose of this paper is to review the successes and failures of ITS in standalone systems and embedded in adaptive learning environments. Elements such as student disengagement and strategies to re-engage the learners using gaze patterns, emotion recognition, voice recognition, and two-way dialogs using voice cloning are considered. These lessons learned are used to predict a future Digital Tutor's design challenges.

Prior Design Decisions for Adaptive Learning Environments and ITS

From the Hornbook to the pointer, the progression of magic lanterns to the iPad, the metamorphosis of Victorian Era Analytical Engine into a laptop, and the evolution of educational/learning technologies have significantly transformed the modern-day classroom. The early 1900s saw a substantial contribution of behavioral psychology to the field of educational technology. Sidney Pressey masterminded the concept of intelligent machines for instructional use in 1924. He was influenced by the laws of maximizing learning, as laid by the famous educational psychologist Edward L. Thorndike.

With the advent of computers in the classroom, the initial belief was that computers, through artificial intelligence, would be able to adapt in accordance with the needs of the learner (Romanuik, 2018). J.R. Carbonell (1970) stated in *AI in CAI: An artificial intelligence approach to computer-aided instruction*, programs like the SCHOLAR system have helped adaptive learning in the classroom. The sole purpose of all the developments in learning/educational technology is to provide quality education to every student. The benefits of one-on-one personalized tutoring have been well researched and documented. Students who received one-on-one tutoring perform on an average of up to two standard deviations higher compared to their peers who receive conventional classroom instructions (Bloom, 1984).

The most effective components of adaptive learning environments that incorporate technology may not be easily determined. Integration of learning management systems (LMS), online courses like MOOCs, educational gamification, virtual reality (VR), or augmented reality (AR) within the adaptive environment could be restricted as powerful teaching tools. Incorporating an ITS within an adaptive learning environment may offer an excellent and cost-effective alternative to one-on-one teaching/learning. The core of an ITS is artificial intelligence

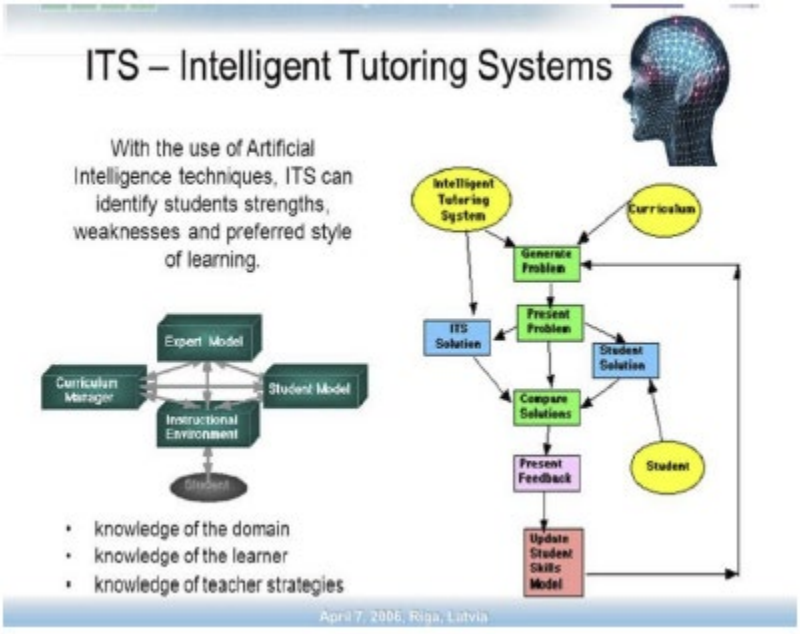
(IA), and according to Ivan Ostrowicz, CEO of Domoscio (2017), its advancements have elevated adaptive learning environments to new heights. He says:

Adaptive learning systems need AI to work, more particularly, machine learning. Therefore, AI, as it is now, is enough to create an efficient adaptive learning technology. With the advancement in AI technology such as deep learning, we can expect adaptive learning systems to be even more efficient than they are today (p. 1)

Before learning more about the ITS as a possible alternative to adaptive learning/teaching, let us look at this educational technology innovation's core features. See Figure 3.1 for a depiction of an ITS integration model and flowchart of essential components.

Figure 3.1

The Intelligent Tutoring System



The ITS is a computer system that aims to provide immediate and customized instruction or feedback to learners (Psotka & Mutter, 1988). It utilizes the applications of artificial intelligence techniques to deliver knowledge to the learner. It integrates four interactive models to identify the learner's strengths and weaknesses and a couple of presentations with learner

preferences. (1) The Domain Model, also known as the cognitive/expert model, contains the knowledge base for lessons and instructions, techniques to deliver concepts, rules, and tutoring strategies. (2) The Student Model traces students' cognitive and affective states, learning preferences, and prior skills then stores this information in the form of data logs. (3) While interacting with the Student's Model data, the Tutor Model prepares suitable tutoring measures with the Domain Model's information help. The techniques used here are based on the adaptive learning environment and personalized tutoring methodology delivered to the learner by the (4) User Interface Model. This integration of data between the four models enables an effective dialog between the ITS and the student while providing the lesson through a pedagogical agent.

Personalized learning amends the learning environment based on student's skills, needs, learning styles, and goals. When applied correctly, personalized learning can move mountains for students (Marshall, 2018). Personalized learning implementation has shown a positive trend toward higher student engagement (DreamBox, 2013). An ITS maintains a rich and up-to-date profile of the student's strengths, style, needs, and progress towards learning goals. The meaningful and appropriate choices concept and material delivery for each student help improve the cognitive thinking process. The constructivism learning theory informs ITS's use in educational applications as the learner is actively involved in meaningful knowledge construction.

In a meta-analysis of 19 different studies to analyze ITS's computerized learning environment's improved effectiveness on the reading comprehension of K-12 students, Xu, Wijekumat, Ramirez, Hu, and Irey (2019) examined the effect of using ITS in the classroom. In their study, a comparison of ITSversus human tutors displayed a Cohen's *d* size effect of an ITS (d=0.76) in line with that of a human tutor (d=0.79). It was also found that the Cohen's *d* effect size was quite significant compared to traditional teacher-based tutoring when the ITS tutoring

was implemented with vigorous intensity for a longer duration. This meta-analysis was carried out on a sample size of 10,000 students. In another study published in the *Journal of Educational Psychology*, the researchers Ma, Adesope, Nesbit, and Hu (2014) reported that 14,321 participants were analyzed on ITS's association and effective learning. The ITS was compared with teacher-led large group instructions, and the Hedge's *g* for the ITS was determined as (g= 0.42) compared to the textbooks (g= 0.35). In contrast, there was no significant difference between learning from ITS and learning from individualized human tutoring (g= –0.11).

The observed improved performance was attributed to ITS facilitated learning using cognitive psychological principles and its adaptive ability to students learning habits. The interaction between the ITS and the student can be customized by diagnosing the student's prior knowledge of the content, his motivation, and level of engagement to the lesson. Thus, ITS creates an adaptive learning environment using modeling, prediction, feedback, and scaffolding strategies, which may not be possible in an over-populated teacher-centered class.

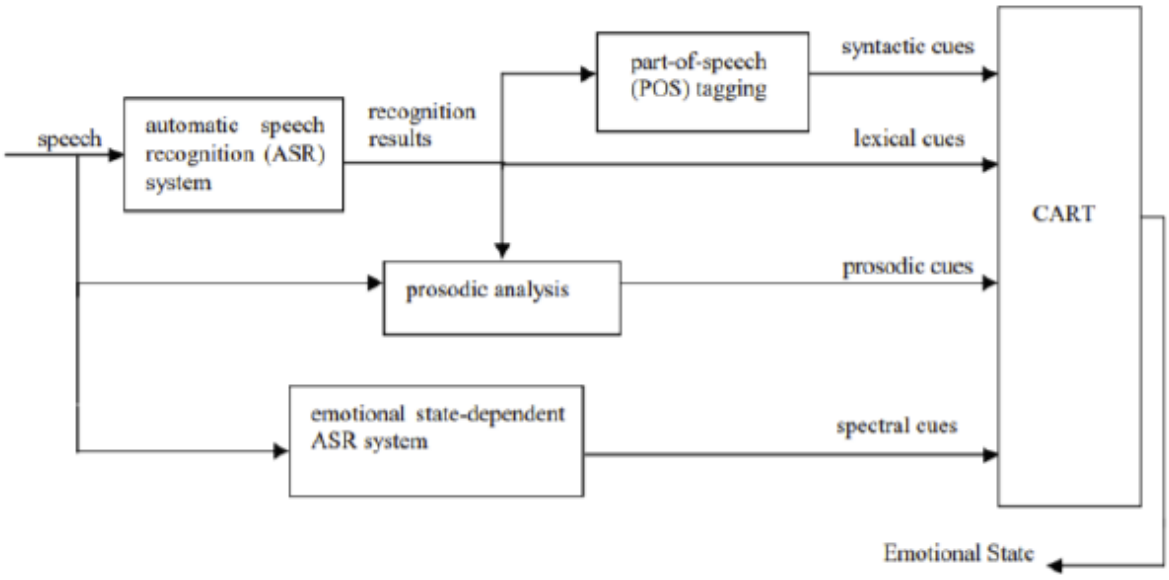
Teachers play a vital role in the lives of students. They build a warm and caring environment in the classroom. They teach and nurture students by mentoring, serving as role models, and invoking a personalized rapport with their students. Opponents of the ITS argue that the ITS fails to build this kind of personal relationship with the students, and hence there would be a decline in the tutoring's effectiveness. The statement may be true to a certain extent. A lively and effective emotional state helps learners promote higher cognitive flexibility and improve the acceptance of new concepts and ideas.

On the other hand, the adverse emotional condition brings about boredom and frustration, which links to declined self-regulation, disengagement, and disturbing learning behaviors. Malekzadeh, Mustafa, and Lahsasna (2015) reported that an ITS could adapt to the learners' affective state (emotional state). Their research further claimed that applying the emotion

regulation strategies during computerized learning may produce more optimistic emotions and better learning gains and performance on the standardized test.

Figure 3.2

Overview of the Emotional State Classifier



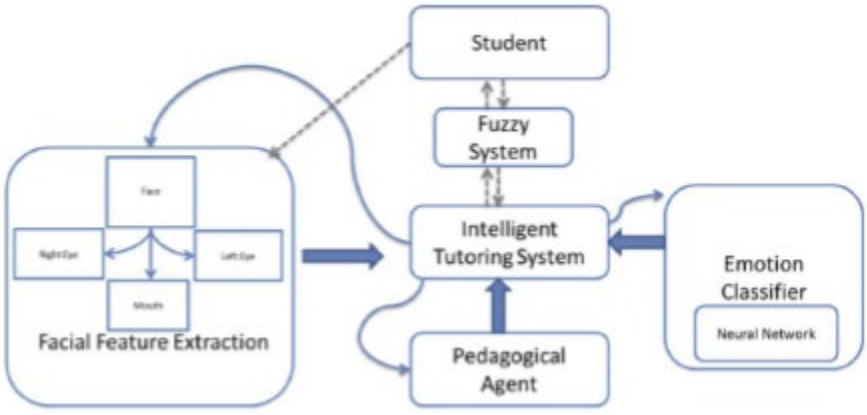
A human tutor maintains a sympathetic relationship with learners in a typical classroom to facilitate positive emotional development. This helps students feel happy. Generally, they perform better in their studies, whereas a typical ITS determines how and what to teach a student based on the learner's pedagogical state. See Figure 3.2 for a depiction of the functionality of emotional state transfer possible within an ITS. The tutoring Research Group (TRG) at the University of Memphis developed a pedagogical agent, AutoTutor, that holds a logical conversation with the learner in natural language (D'Mello et al., 2005). The full explanation of the working of the AutoTutor is beyond the scope of this paper. Still, as briefly described, it engages students with the curriculum script stored in the Domain Model's knowledge base. This ITS ability to detect learners' unpleasant emotional states has been found to foster improved learning. The technologies involved in this process were the Automatic Speech Recognition

System, Part-of-Speech tagging, Prosodic Analysis, Syntactic, Lexical, Prosodic, and Spectral Cues.

Another component of ITS, gaze recognition, can promote engagement and learning by dynamically detecting and responding to students' boredom and disengagement. See Figure 3.3 for the gaze recognition process. D'Mello, Olney, Williams, and Hays (2012), incorporated a commercially available eye tracker (Tobii-T60) in the ITS. This gaze pattern identifier could detect boredom, disengagement, or the zoning out of the student. To counter the opponents' argument that the ITSs are not as effective as human tutors in promoting students' engagement, motivation, and interest in learning, the developers conducted a study involving 48 subjects to test the effectiveness; it was determined that gaze-sensitive dialogs were useful in learning gains compared with non-gaze ITS versions.

Figure 3.3

The Gaze Recognition Process



D'Mello et al. developed an ITS with a commercial eye tracker (Tobii-T60) to measure students' disengagement from the lesson due to boredom. The gaze patterns were used to determine the student's zoning out of the lesson. An effective dialog by the animated pedagogical agent was produced using a voice engine to re-engage the student in disengagement.

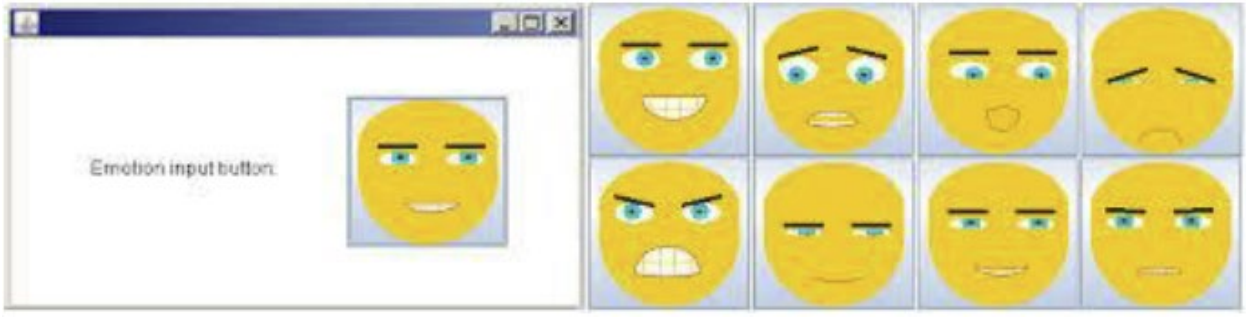
These measures also helped students in learning where deep reasoning was needed. The study measured learning gains and students' engagement with the lesson. It was expected that with the gaze-pattern recognition, engaging students would effectively make a positive learning gain. This expectation was confirmed in multiple analyses that showed a substantial correlation between proportional focus on the tutor and deep learning gains. The results yielded an (r=.362, p=.042) and overall learning gains (r=.465, p=.007; D'Mello et al., 2012).

On the contrary, sentiments play an essential role in the learning process. Suppose a learner does not understand the lesson due to anxiety, exasperation, nervousness, or depression. In that case, these circumstances can lead to boredom and the non-clarity of the concept. The ITS uses previous and current log files and the self-assessment AffectButton Tool to measure the student's state of emotion to integrate sentiment within the learning environment. The

AffectButton is a self-report tool that enables users to report their emotions, mood, or attitude about things. It is a simple interactive button that presents a dynamically changing facial expression. (Broekens, 2014)

Figure 3.4

The AffectButton Tool



Behavior patterns like "Pleasure" (pleasant feelings towards lesson), "Arousal" (energy level of the learner), and "Dominance" (ability to cope with the new concept) are measured by the AffectButton Tool using the computer's built-in webcam (Brookens, n.d.). The ITS's

algorithm compares the learning effect size and recorded emotion recognition log files to the Domain Model, which delivers a tweaked lesson and enhanced learning. See Figure 3.4 for an example of the AffectButton Tool.

Discussion

The prior studies and AI-based ITS tools may establish that an ITS with the gaze recognition pedagogical agent and AffectButton Tool could maintain a beneficial learning environment and be as effective as a human teacher.

As an innovation in the learning/educational technology, ITS could be an effective system in eradicating illiteracy from the world. There are 785 million illiterate people globally, with 150 million children to follow because they do not have access to education (UNESCO, 2017). An ITS could offer a solution to this world menace. There are clear benefits of e-learning. When schools are scarce or adequate tutors are absent, an ITS implementation could provide access to quality education by leveraging cellular and WiFi communication channels. The technological solution could reach the masses and educate them, allowing them an opportunity to learn.

As of 2018, more than 95% of the world has access to mobile networks (Ericson, 2018). Now that more than 85% of the world's population has some form of cellular or WiFi connectivity, the depth of mobile penetration has reached a tipping point for an ITS to be used through mobile communication to deliver education to the masses. The ITS would incorporate audio/video technologies to present educational lessons. When adequately delivered and utilized, the instructional design and implementation would leverage Mayer's multi-modal theory, and the approach would take advantage of the dual-coding learning theory (Wang & Shen, 2012). Connecting the ITS through a web-enabled device would be a much more efficient teaching

mode when no school or teaching professionals were available. In addition, an ITS could be integrated into a non-traditional educational environment such as a community center, home, library, or home. Within the Education Dominance Program, an education initiative of the Defense Advanced Research Projects Agency and the United States Navy, the ITS has proven to be an excellent choice for training purposes. The students increased their cognition of concepts and moved through the assignments faster than traditionally taught students (Budd & Best, 2007).

ITS, however, requires a substantial amount of work in its development. The hardware could be expensive, and the development of four ITS models requires intensive consultation with subject matter experts, course developers, instructional designers, educational psychologists, and recruitment expert software developers. Simultaneously, the cognitive task analysis, setting up problem-solving strategies, integrating multiple components, testing before deployment, and commissioning the production model could prove very time-consuming and costly. Costs associated with the delivery and reception of the lessons by the end-user could also be expensive.

Conclusion

Apart from the significant amount of work and associated costs, the ITS development follows a typical instructional design process. Corbett et al. (1997) summarized ITS design and development as the ADDIE model's five phases: Analysis, Design, Development, Implementation, and Evaluation. Once the developed ITS has been deployed, the overall costs for and benefits of the ITS-based educational implementation could be managed by reducing the need for physical schools, eliminating inadequate educators, modifying educators' training, improving logistics, and offering easy access to quality education. The comprehensive benefits could easily justify the initial costs of development. In areas with limited access to specialized

instructional skills or as a cost-saving measure, an ITS could be utilized in education and corporate training, language tutoring, and educating special needs students. With all these uses and benefits, ITS can be less expensive in the long run.

The problem of illiteracy has plagued the world's poorest nations like an epidemic. In a digital tutor in an adaptive learning environment, the intelligent tutoring system may offer an alternative solution for educating the masses. Moreover, in a traditional educational setting, providing a tutor for each student would be ideal but certainly might not be reasonable in terms of financial and other circumstantial constraints. An ITS has the capacity to provide students with experiences similar to those offered by a tutor at a fraction of the cost. Based upon projections of the reviewed literature, this is where educational technology is likely leading educational programming and environments in the future. At this time, the ITS might not have been adopted fully by the education community in the advanced world (Ferster, 2017), but it can prove to be very effective in the developing world (Nye, 2015). Educators and policymakers in developed and developing areas of the world should consider this novel's potential influence and potentially resourceful knowledge delivering methodology, its interactive knowledge delivery, and its role as a teacher, facilitator, and mentor.

As advances in AI technology continue to push the boundaries of what's possible, the education sector will likely feel the benefit (Savage, 2017). ITS's successes and failures in standalone systems and embedded in adaptive learning environments offer examples and strategies for managing learner disengagement. Students using future digital tutors in an ITS or within an adaptive learning environment would re-engage using gaze patterns, emotion recognition, voice recognition, and two-way dialogs with voice cloning. The implementation of the lessons learned is informing the future Digital Tutor's design and implementation solutions.

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CHAPTER 4

THE DIGITAL TUTOR: AN EDUCATIONAL TECHNOLOGY MARVEL. A FUTURISTIC ANALYSIS OF A MODERN INTELLIGENT TUTORING SYSTEM

Abstract

The COVID-19 pandemic wiped off decades of educational gains in the developing world and added 24 million more children to 775 million illiterates in the world. To counteract such a huge predicament, human learning agility comes into action. This human characteristic of knowing what to do when one does not know what to do, invokes the Soft System Methodology (SSM) approach to analyze illiteracy as the worst of all pandemics since it infiltrates into generations. After evaluating different effective teaching methods and utilizing the SSM approach, this paper proposes suitable pedagogies to educate deprived students. It examines Massive Online Open Courseware (MOOC) as a viable solution for K-12 students and compares it with a more robust educational technology model of Intelligent Tutoring System (ITS). Using artificial intelligence, the ITS tailors the instructional content framework and teaching strategies after evaluating students' pre-existing knowledge, learning habits, & styles. The ITS engages the student with the lesson with a two-way dialog while providing customized instruction and immediate feedback. An ITS requires no human intervention and could be a suitable replacement for an inadequately qualified teacher or no teacher. Hence it could be a practical tool in tackling the global literacy catastrophe. A comprehensive literature review followed by a meta-analysis reveals the effectiveness of ITS as a feasible intervention. The major purpose of this study is to define the application of educational pedagogy behind AI-based tutoring and cognitive science in this learner-centered approach.

Keywords: learning agility, soft system methodology, effective educational pedagogy, MOOCs, intelligent tutoring system

Introduction

One year into the COVID, the world saw many challenges which may pose a great threat to human development. Besides the astronomical number of deaths, millions face severe poverty, hunger, a wide variety of health issues, an intense slowdown in economic growth, and a sharp decline in sustainable human development goals. One of the pitfalls of this catastrophe is that millions of school-age children have been dropped out of school and are added to the list of 775 million world illiterates. One year of the pandemic has wiped away two decades of economic growth (UN Foundation, 2021) and decades of educational gains of the pre-epidemic era (UNESCO, 2021). It was speculated that 24 million affected students might never go back to school (Rang-De-India, 2021).

Figure 4.1

Learning Agility Explained

The old Chinese proverb, “When the winds of change blow, some build walls while others build windmills.” (para, 1), is a good example of a human attribute known as *Learning Agility*. Knowing what to do when one does not know what to do, characterizes humans as humans. Rejecting metathesiophobia as a response to a challenging situation gives rise to learning Agility. This innate feature of humans is not an acquired skill; rather, it comprises five sub-skills: 1) the aptitude to quickly analyze the complex problematic situation and construct a deep understanding of the problem (Mental Agility), 2) The ability and willingness to transform the situation (Change Agility), 3) Knowing one’s strengths and weaknesses (Self-Awareness Agility), 4) Involving all stakeholders in finding possible solution/s to the problem (People Agility), and 5) Delivering the solution by responding to the challenging situation (Result Agility).

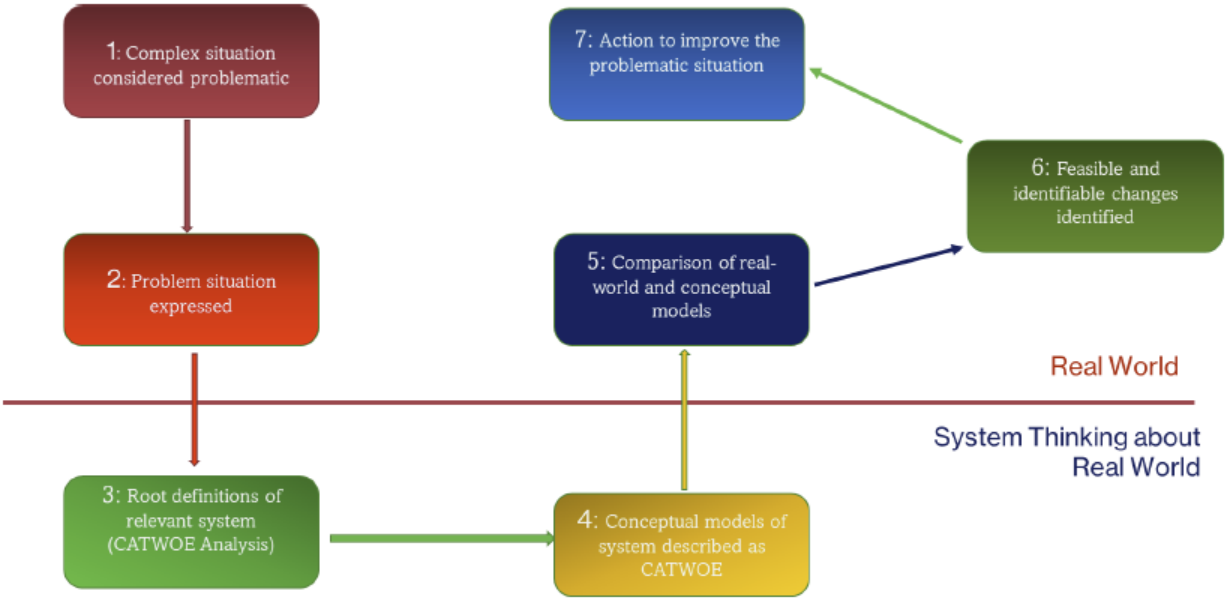
A complex situation involving educating millions of deprived children is not an easy one to manage. Multiple governmental and global organizational efforts have successfully reduced illiteracy, but the enormity of this complex situation has not produced decent results. The Poverty Research Center (CPRC, n.d.) reports that the menace of poverty and illiteracy infiltrate into generations due to its influence on children. About 70% of the global poor aged 15 have no schooling or have basic education only (The World Bank, 2021). In another report, the World Bank (2020) stated that 72 million additional primary students would suffer from learning poverty, meaning that children by the age of ten could not read simple text or draw an understanding. Oscar Lewis (1966) postulated that the culture of poverty and illiteracy, once started, is likely to continue into generations unless there is outside intervention.

A vigorous outside intervention could be the only option to tackle this situation. Such an action would require an application of soft system methodology (SSM). According to Peter

Checkland (2006), the "Soft Systems Methodology" is a method to structure complex problems and to develop desirable and feasible changes within a differentiated group of people" (p. 1).

Figure 4.2

Stages of Soft System Methodology Approach



SSM analysis tries to unfold problematic relationships within the system to enable better decisions (Jackson, 2003). The SSM approach follows a seven-step process:

Step 1 – Complex situation considered problematic: Analysis of the problem situation. Gather all the information about the system of interest, situation context, and content using empirical research. In this case, the issue is related to the 775 million illiterates in the world.

Step 2 - The problematic situation is defined: After all the information is collected, the problematic situation is defined in text and a rich picture diagram. This step defines the situation of educating millions of underprivileged children in developing countries.

Step 3 - Formulation root definitions of the system: (CATWOE analysis). This step describes the ideal way the system should function. In the real-world educational system,

technology is playing an important role in educating the masses. This includes online classes, mobile learning, open educational resources, & MOOCs, to name a few.

The acronym CATWOE is defined as, C: the Customers: Users of the system of interest (students/learners); A: the Actors: Schools, Teachers, Self-leaners, Online Education, CBT, MOOCs; T: the Transformation process: Institution education is transformed into literate students with HS-Diploma awarded; W: the World View: Graduation (the Diploma). Evidence that the graduates possess standard proficiency and skills in the domain of qualification; O: the Owners: The people in the system benefited from the change (The literate world; and E: the Environmental Constraints: Elements that can influence/limit a constructive change in the system - Cost of providing quality education, poorly implemented educational programs, inadequate educators, lack of interest in education, poverty, child labor, geopolitical and cultural restrictions.

Step 4 – Conceptual Alternatives: When the real-world implementations cannot achieve the desired outcome, the SSM considers conceptual alternatives as an intervention. This paper evaluates the Intelligent Tutoring System as a possible intervention.

Step 5 - Comparing conceptual and real-world models: The conceptual models could be a theoretical models are still being developed and evaluated. A comprehensive evaluation using empirical research compares the two models and recommends its implementation based on scientific evidence. The paper discusses MOOCs vs. ITS in this respect.

Step 6 – Identifiable and feasible changes are defined: The conceptual model is evaluated based on how it will positively change the system. The ITS is thoroughly appraised at this as a possible intervention.

Step 7 - Action is taken to improve the SOI: Implementation is taken to improve the problematic situation with a consensus of all involved in the system. AI-based ITS is

implemented as an alternative to human tutors for educating students.

A review of the current efforts in teaching the masses can significantly benefit from MOOC application in education. This free courseware platform is available online for anyone to take advantage of. Coursera, edX, Udacity, and many other MOOC providers have been a great pivotal source of quality education. Coursera mostly focuses on professional and technical training, whereas edX specializes in humanities and natural sciences (Edukatico, 2020). Students can audit the classes for free or get a completion certificate for a fee. MOOCs are collections of learning objects linked to general learning goals (Spector, 2014). Spector (2014) also reported that MOOC's proper assessment might not be termed instructional objects due to formative and summative assessments.

In any educational setting, timely constructive feedback is a key factor in achieving competency. It helps students in making changes in their learning strategies and boosts confidence. Effective feedback supports concept retention, motivates them to focus better, and hence they progress better in their studies. Due to the cost-free nature of MOOC, providing timely feedback in a MOOC class with hundreds of students is an impossible task. Automated approaches have been implemented with specific data analytics, but these are not effective in providing personalized feedback. Some semantic auto-grading software like CLARA (Singh, Gulwani, & Sola-Lezama, 2013) and AutoGrader (Gulwani, Redicek, & Zulegar, 2016) are being used in computer programming MOOC courses. However, these are not effective for novice programmers.

A mini-MOOC is a shortened version of the full-scale MOOC (Vassiliadis, 2018) targeted to highlight a specific topic. The concept is still in its infancy and is in the development stage.

On the other hand, blended learning environments have given rise to personalized

learning (Watson, 2008). ‘‘Students should be at the center of learning because there is no other place they could be” (Dowens, 2015). A predefined MOOC content could be personalized for the learner (Hu, Miao, Leung, & White, 20170. AI-based personalized MOOCs system resulted in the development of micro-MOOC. The contents are developed using backward design, in which course objectives and evaluation criteria are determined first before developing the learning contents (Childre, Sands, & Pope, 2009). Short micro-MOOCs providers like Curious, Pathwright are appealing to working professionals for their personalized content. Regrettably, these features don’t come for free. These are available as paid MOOC’s bachelor’s and master’s degree offerings. The tuition of MOOC-based degree courses ranges from $10,000 to $44,520 (Ledwon, 2021), which defeats the MOOC’s concept.

MOOCs for K-12 Students

MOOCs could be a viable solution to eradicate illiteracy from millions of children in developing countries. It offers free and easy access to thousands of courses in almost all subjects and can reach the target population via an online platform. MOOCs are a great resource in concept building for K-12 schoolers. From algebra to physics, language arts to accounting, economics, and world geography, more than 4,000 courses are available to take for free (Edukatico, n.d.). Khan Academy, E-learningforkids.org, DIY.org, Gcflearnfree.org, Coursera, and edX are a few of the many course providers for school children. Most of the courses are for concept building only and cost money for school credit. tA typical high school MOOC course could be as expensive as $350 (Moon, 2019). Again, it is not an option for a student living in poverty conditions.

Besides the costly school credit courses, there are significant limitations in MOOC’s offerings. Let us review a few of them:

- MOOC is Not Structured: Like higher degrees granting (Bachelor/Masters) institutions, none of the providers has utilized MOOC content in a K-12 structured online institution. Fee-based structured accredited institutions award diplomas and completion certificates. But these are expensive, with tuition exceeding $8,000, which is not affordable for the target population.

- No fee K-12 MOOCs are Not Standardized: A diploma-granting institution requires state and governmental accreditation to award high-school completion certificates. The certification guidelines ensure that the institution meets minimum governmental education standards to provide quality education, hence a completion certificate or a diploma. There are no accredited MOOC-based schools available or free. In addition, the governmental accreditation standards have not been set yet for certifying such institutions.

- MOOCs have no No credit-earning standards. Reward and punishment act as the guiding principles of human behavior. In the absence of a completion diploma/certificate, MOOC-based education could only be used as a supplementary education.

- MOOCs offer No Personalization: There is no personalized MOOC available for K-12 students. Mini/micro-MOOCs are targeting only adults and professionals.

- No Standardized Assessment: There are no periodic assessment standards available for MOOCs to evaluate learner's mastery of the subjects. Only a completion certificate could be granted, which does not fulfill a high school diploma requirement.

- MOOCs offer No Feedback: Feedback keeps students adjusting their learning strategies, boosts self-confidence, and motivates learning. MOOCs lack this great feature of educational mindset.

- No Engagement in MOOC: The impersonal nature of MOOCs does not offer a student any engagement strategy to the course.

- No progress checking: Keeping students on track is not available on this one-way delivery of lessons.

- Very Low Completion Rate: Due to the free nature and limitations mentioned above, MOOCs have a very low completion rate. These factors are a great deterrent to the students. An MIT study (MIT Pivot – 2019) shows a 3.13 completion rate among MOOC students (Reich & Ruipérez-Valiente, 2019).

Pedagogical Approaches in Educational Technology

Educational pedagogy is the principal approach that influences the delivery of knowledge, learning, and assessment. It is the theory of learning and teaching involved in the

development of learners. It involves various techniques in a whole class structured group work, guides learning and individual activities in the learning process. Online education, like MOOCs, could be related to Effective Pedagogy, which emphasizes student-centered teaching and learning. In addition, online learning takes advantage of Digital Pedagogy (Reaves, 1999), incorporating technology as a tool for learning and teaching. The digital pedagogy has its roots in Piaget's (1990) Constructivist Pedagogy that puts the child at the center of learning and is a likely answer to the research question; `Which educational pedagogy would be best suited for distant learners?

In the absence of adequately trained teachers, learner-centered instruction is an effective pedagogical approach. It empowers students to seek and retain knowledge, develops problem-solving skills, enhances collaborative learning, and facilitates personalized learning (Asoodeh, Asoodeh, and Zarepour, 2012)

Teaching the Masses: A SSM Conceptual Approach

An SSM analysis of the current approach in online education (MOOCs) shows that it may not be a feasible solution for the targeted population due to its non-accredited unstructured model. MOOCs and other educational models like m-learning, media Datacast have unstructured courseware, no preliminary or periodic assessments, and poor administration. Adaptive teaching techniques would be efficient for most of the students. With the current education delivery methods, these elements are not possible. A futuristic analysis of the SOI recommends an AI-based teaching model of Intelligent Tutoring System (ITS). With the following features, the ITS is a very likely contender in educating the target student population:

The ITS employs artificial intelligence and machine learning technologies to offer:

- Personalized tutoring using student's learning skills, habits & styles, and mood patterns

- Customized lesson plans for all types of students
- Provides immediate assessment and feedback
- Keeps students engage with voice and gaze recognition
- Virtual pedagogical agent; capable of two-way dialog, acting as a human teacher
- Can reach the masses at distant where schools are not available
- A well-balanced non-human tutor for female students who get deprived of education due to cultural and customary restrictions (Rural Pakistan/Afghanistan as an example)

The Digital Tutor – The Virtual Pedagogy Agent – A Human Tutor Substitute

Brick-and-mortar schools may not be available in most developing and distant regions of the world; due to financial constraints or inappropriate educational policies. Availability of qualified teachers or no teachers is also a troublesome issue. An ITS could offer a viable alternative answer in educating the masses. The Digital Tutor (DT) is the face of an ITS that interacts with the learner in the learning process. A detailed description of the DT is discussed in the User Interface Model of the ITS. The conceptual model of SSM stage six is explained below:

The Intelligent Tutoring System

The ITS is a computer-based personalized tutoring and feedback educational system that replicates the role of a human teacher working as a lesson planner, course deliverer, and feedback provider. The lesson is delivered by the user interface (the DT), using a customized lesson plan. The concept of ITS is drawn from the "… work in cognitive psychology, computer science, and especially artificial intelligence" (Larkin & Chabay, 1992). It follows the practices of expert human tutors (Woolf, 2009). In the process of teaching, it distinguishes between a correct and incorrect response from the learner, adapts dynamically to the response, and redelivers the concept with alternative solution/s.

An ITS is an adaptive, interactive, and learner-paced learning environment created using computational models developed in the learning sciences, cognitive sciences, mathematics, computational linguistics, artificial intelligence, and other relevant fields (Graesser, Conley, & Olney, 2011). The ITS works on the idea of "diagnose errors and tailor remediation based on the diagnosis" (Shute & Psotka, 1994). In case of a correct response, the lesson can be customized to challenge the student by raising the difficulty level of the instruction. In addition, educators can set up a reward policy for advanced learners, who can take advantage of these challenges and earn extra assessment points. This is an example of reinforcement learning (Osiński and Budek, 2018) and can help slow learners.

However, there is a belief that even though the Intelligent Tutoring Tools had positive feedback from many institutions, the underlying methodologies used for developing an ITS were not designed from an educational viewpoint and hence did not possess all the attributes necessary to fulfill educational objectives (Kinshuk, 1990).

Components of ITS

A modern ITS is built on four basic components, also known as ITS Models (Nwana, 1990, NKambou et al., 2010)

- The Domain/Expert Model (Knowledgebase of concepts, tutoring strategies): This module is designed to accommodate expertise information that would be used in aiding the ITS to deliver expert flow (Nkambou, Frasson, & Gauthier, 1998). It also acts as the source of the courseware (McNally, Shute, & Psotka, 1996; Frasson & Aimeur, 1998; Self, 1999).
- The Student Model: (Student learning tracer): Any deviation alerts the Domain Model; Adaption to learner's needs). To identify learner's capabilities, logs of prior knowledge

on the subject, misconceptions, learning patterns are stored in this model (Ayop, Chellappa, & Nalena, 2001).

- The Teaching Model (Teaching options maker): With the help of Student & Domain Models, the Teaching Model controls the lesson delivery, assessments). A corrective measure is taken in case of an incorrect response. For accurate responses, this model has controlling access to the subject matter in the knowledge base (Frasson & Aimeur, 1998). Queries and solutions are handled at this level.

- The User-Interface Model (The face of ITS): Using natural voice recognition techniques, the UI Model delivers the lesson while engaging the student with a two-way dialog. It gives feedback to the Teaching Model about student's progress and engagement to the lesson. It is also responsible for offering resources and interaction with the learning platform (Salgueiro, Costa, Cataldi, Lage, & Garcia, 2005), thus making the content understandable to the learner (Shure & Psotka, 1995).

ITS Feedback Process

Effective feedback is critical for building students' confidence, self-awareness, and motivation towards learning in any learning environment. With constructive feedback, students can modify their learning strategies and plan their studies accordingly. Timely feedback allows the students to reflect on their performance and motivate them to make certain changes to improve their performance (Briggs, 2014). The ITS provides immediate feedback to the learner. Depending on the settings, it can highlight wrong answers and provide hints to solve the problem/s.

Unbiased Assessment and Analysis of Future Performance

ITS assessments are carried out without any bias. These are based on student skills and

performance. It provides authentic and reliable assessment (Lynch, 2018). An ITS can also indicate alarming changes in students' performance (Lynch, 2018) by providing insight into current progress and future performance trends. Measures can be taken to correct any deficiency.

The Cognitive Science Behind the Digital Tutor

Constructivist and Digital Pedagogies

With ITS, the learner actively participates in the learning environment, i.e., learning by doing; (Aleven & Koedinger, 2002). ITS generates functional techniques, offers concept explanations, and justifications on knowledge gains. This process constructs deep learning due to causative explanations, as compared to applying perceptions by mere reading. ITS also offers immediate feedback by adaptively correcting the learner verbally (Grasser et al., 2001). This guidance is based on the knowledgebase concepts and strategies already stored in the Domain Model.

Naturalistic Tutoring

Like a human tutor (Chi et al., 2001), the ITS performs collaborative, constructive teaching and learning with two-way dialogs. The expectation and delivery of rightful answers are common both in human tutors and ITSs (Graesser, Person, and Magliano, 1995). Lepper & Woolverton (2002) claimed that human tutors deliver lessons more efficiently and assess their students' effective learning. Van Lehn (2011) rejected this assertion as he demonstrated that ITS is more effective for customized learning and unbiased assessment.

The Architecture of a Modern ITS

A modern ITS could be termed as integration of intelligent agents (IA) and semantic web that works on rules. An IA is an AI-based autonomous entity that learns activities of a system

using observations, repeated actions and queries the knowledgebase to deduce an action plan (Anderson & Anderson, 2007). The DT acts as an AI, as it uses input sensors like webcam, microphone, keyboard/mouse, and other devices to perceive the learner's actions to plans steps, strategies, assessments, and feedback in the teaching process.

Rules: The ITS works on the IF-THEN-ELSE rule (Dillenbourg et al., 1994) to identify student's knowledge and plans pedagogical strategies for the lesson. If the student's knowledge is equivalent to rules [a, b, c], then teach him a lesson from rule [d], else teach using rules [a,b,c,d]. On the other hand, the knowledgebase acts as the semantic web cluster in the ITS.

DT (using voice recognition engine) passes the inquiry to the student model, which interacts with the Domain and Tutoring models to find the answer and deliver it. Machine learning techniques using inductive, deductive, and analogical algorithms (Kodratoff & Michslski, 1990) record effective strategies to teach the students. Most ITS are built on Expert Systems using LISP and PROLOG computer languages. Java, Pythons, and Objective C. are used in Natural Language programming, whereas Java, Python, and C++ are used for Graphical User Interface programming.

Two-way dialog is with text to video technology is quite effective in engaging the learner. For example, Neural Voice Puppetry (Thies et al., 2020) is an audio-driven facial video synthesis that produces a 3D video output of a virtual teacher with the mimicking voice of any source. This technology advances the Lyrebird.ai, which used only the synthesized cloned voice of a celebrity in the teaching process.

ITS used in the educational world

- Algebra: Cognitive Tutors (Koedinger, & Corbert, 2006), PAT (Koedinger, Osborne, & Gaebler, 2021)
- Statistics: ALEKS (Falmagne, 2013)

- Mathematics: AnimalWatch (Beal, 2006)
- Physics: Why/Atlas (VanLehn et al., 2002)
- Computer Prog: ACT Tutor (Corbert, 2001)
- Medicine: ACLS Cardiac Tutor (Wolf, Beck, Eliot, & Stern, n.d.)
- Engineering: ElectronixTutor (Gracer et al., 2018)
- Comp. Networks: DARPA Education Dominance (Fletcher, 2011)

Meta-Analysis: Building a Case for the Conceptual Model

Why use an ITS? That is a valid question that a stakeholder from the SOI can ask. ITS features and comparison have already been discussed earlier, but is it effective as mentioned? A thorough statistical analysis can prove or discredit this assumption.

Using meta-analysis lets us draw conclusions that an ITS could be a good fit for this problematic situation. Meta-analysis is an important aspect of a quantitative study that is designed to assess previous research systematically. The purpose is to derive a single summary effect of multiple studies, answer questions that were not satisfied in previous studies, generate new hypotheses, and derive conclusions about the new domain. The meta-analytic process helps researchers explore the research realm by preserving statistical significance and minimizing data losses. It also allows blending results from a few or many studies, the accurate estimate of descriptive statistics (Hedges 1987, Rosenthal 1978).

The conclusions from meta-analysis could be more accurate and credible than in one study or qualitative narrative evaluation. A meta-analysis also helps to identify the moderator variables that might have a causal influence on the effectiveness of the study. The moderators in this study are the length of study time, human intervention, and assessment types.

Research shows that the application of technology in education has a large effect size (.93

and 1.28) on learning (Xu et al., 2019). The SSM approach used here to educate the children requires identifying the right educational technology that can capture students' attention, deliver adaptive tutoring, provide instant feedback without any human interaction, or in the absence of adequate teachers. Researchers in education (Ploetzner and Lowe, 2004; Ainsworth, 2008) have begun to identify a need for more fine-grained research studies that capture the subtleties of learners' interactions with dynamic and interactive tools. An ITS does fit these criteria. A meta-analysis of different studies would be necessary to find the effectiveness of this educational technology.

What Does Effect Size Tell Us?

Effect size is a significant factor in a study. The magnitude of that measures the strength of the relationship between two variables (Kelly & Preacher, 2012). The quantitative measure of the magnitude of the experimental effect directly answers the research questions that motivate a study (Pek and Flora, 2017). A larger effect size indicates that the study outcome has a practical significance that can be applied as an intervention in the real world. So, the statistical significance of the research is denoted by p-values, whereas practical significance that can be applied is represented by effect sizes (Bhandari, 2021). Gene V. Glass mentions, "Statistical significance is the least interesting thing about the results. You should describe the results in terms of measures of magnitude –not just, does treatment affect people, but how much does it affect them." (Kline, 2004). The substantive significance of a result, in contrast, has nothing to do with the p-value and everything to do with the estimated effect size (Ellis, 2020). Jacob Cohen (1997) also has the same kind of comment, "The primary product of a research inquiry is one or more measures of effect size, not P values."

Hedges's g method would be a preferred choice to calculate the effect size, over Cohen's

d, due to the small sample sizes in the reviewed studies. Whereas, when dependent variable measured in different ways like; self-reporting of educational gains; different methods of assessment used, Cohen's d method is preferable.

$$\text{Hedges' } g = \frac{M_1 - M_2}{SD^*_{pooled}}$$

where:

$M_1 - M_2$ = difference in means.

SD_{pooled} = pooled and weighted standard deviation.

Interpreting Results

Cohen's and Hedges's results are interpreted on the same scale. Cohen (1977) suggested that effect sizes of .20 are small, .50 are medium, and .80 are large.

Due to many studies reviewed in the meta-analysis, Comprehensive Meta-Analysis Software was used to calculate the combined pooled effect size.

Identifying Moderator Variables

It is important to analyze the potential causal effects of the moderator variable/s. These help us understand why there was an unexpected difference in results. For example, study time, human intervention (teacher/blended), different assessment types were checked as variables that might have a causal influence on the effectiveness of the study.

Considerations in Meta-Analysis Literature Review

In this meta-analysis, an electronic search of databases resulted in more than 150 plus journal articles, conference proceedings, dissertations and thesis, books, and book chapters. Using inclusion criteria, screening was done using the names of ITS. Some 52 individual studies

on different ITS models were separated on the overall effectiveness of ITS. The examined studies ranged from 1990 to 2018, with up to 18 months for the ElectronixTutor. The literature search showed that multiple terms were used for ITS instructions, like; computer-based training (CBT), computer-aided instructions (CAI), eLearning. Reviewing of those papers revealed that ITS is a superset of CBT, CAI, and e-learning. It integrates domain knowledgebase and infinite interactions between the learner and system (Graesser et al., 2011). The studies were distinguished and selected using the following terms:

- Domain related knowledge in CBT/CAI
- eLearning vs. human tutors
- Student-centered learning
- Use of AI in education
- Interaction with the system
- System providing feedback
- Communication through a user interface,
- ITS terminologies (SQL tutor, Andes tutor, Cognitive tutor, and others ITSs)
- Declassified papers from DARPA, and other military institutions
- Studies with measured ITS effectiveness, and effect sizes

The ITS evaluated were AutoTutor (Graesser et al., 2005), SHERLOCK (Lesgold et al. 1992), ElectronixTutor (Gracer et al., 2018), Gaze Tutor (D'Mello et al., 2005), Dragoon, eXtended Tutor, ALEKS (Falmagne et al. 2013), Andes (VanLehn 2011), Why/Atlas (VanLehn et al., 2002), Cognitive Tutors (McGuire, & Morgan, 2007) and others.

The meta-analysis consists of studies using different criteria like control groups, ITS types, various intervention methods, subjects (algebra, engineering, medicine, and more), and

moderators. The overall pooled effectiveness was measured using random effect size. This meta-analysis included both pre/post-test differences and post-test-only effect sizes.

The effectiveness of ITSs was compared with the following criteria

- Comparison (control groups)
- Different types of ITS (ALEKS, ElectroniX-Tutor, Conative Tutor, Why/Atlas, and others)
- Interventions (ITS only, Blended, Assignment assistance)
- Subjects (Algebra, Statistics, Engineering, Medicine)
- Moderators (Teacher/blended, study time, Assessment types).
- Coding

The following Keywords were used for coding different studies:

- Modes of ITS intervention in different settings:
    - Only ITS: ITS-Only
    - ITS with classroom instruction – ITS-Blended
    - ITS as a supplement after instruction: ITS-Supplement
    - ITS in lab period: ITS-Lab
    - ITS as a tool in assignments: ITS-Assignment
- ITS assisted learning vs. other modes of learning
    - Computer instructions (CAIs) – Online one-way dialog/commentary
    - Regular classroom instruction
    - Self-study textbooks and other printed material
    - Learning from digitized material, eBooks, pdf documents
    - Self-learning, including labs, assignments, class notes.
    - Human tutoring

When pooling effect sizes in Meta-Analysis, there are two approaches which we can use: the Fixed-Effect Model or the Random-Effects Model (Borenstein et al., 2011). Since each study used its heterogeneity and a random draw from multiple population effect sizes, a random effect model would be best suited (Pigott, 2012). After reviewing all the studies, it was preferred to use random effect meta-analysis due to the heterogeneous nature of the studies. Multiple ITS were evaluated with multiple comparisons, interventions, multiple settings, and sample population. In a random-effects model, the effect sizes synthesize multiple distributions of effect sizes with a normally distributed mean and variance (Pigott, 2012).

Publication Bias

Publication bias occurs when results of published studies are systematically different from results of unpublished studies (Song, Hooper, & Loke, 2013). A systematic review of unpublished articles, book chapters, doctoral dissertations, masters' theses, and inclusion criteria was conducted using google and google-scholar searches to avoid a publication bias. Data from some of these documents were included in the CMA software for effect size calculation. CMA software failed to generate a funnel chart due to some technical faults in the program.

Results

In this meta-analysis of multiple studies, the effect sizes were mostly mentioned in Hedges's g. Some studies had only one comparison condition, and some had two. Considerations of variation in study outcomes and heterogeneity were employed while pooling the combined effect sizes. The CMA software gave a very thorough assessment of the combined effect sizes on those different conditions. Since the sample sizes in the studies were small, Hedges's g random-effects model was the preferred method used in the CMA software. All the data was entered in the CMA software, and the following results were tabulated.

Table 4.1

ITS Effectiveness by Comparison (ITS vs Other Modes of Learning)

Comparison (ITS vs)	Confidence Interval (95% CI)	*p* - Value	Effect Size (Hedges's *g*)
Classroom Instructions	[.23, .61]	.000	.51
Self-Study (Text, notes, etc.)	[.41, 1.18]	.001	.91
Computer Assisted Learning	[.21, .65]	.003	.48
Digitized Material Learning	[-.03, .39]	.059	.51
Human Tutoring (1 on 1)	[-.39, .42]	.297	.20

Note: *p*-value < .001 is listed as .000

Comparison conditions were grouped tother in the studies. Computed results in Table 4.1 show that ITSs were very effective when compared with self-study (*g*=.91). On the other hand, the ITSs showed very little effectiveness (g = .20) when compared with one-on-one human tutoring. One-on-one tutoring is ideal in a learning environment but not a feasible option. An ITS offers that feature using AI-based virtual tutoring; hence could be a very practical remedy to educating so many children. Other comparisons vary from a positive Hedges's *g* (.38) to *g* (.51), and except for the one-on-one tutoring (*p*-value=.297), all the other effect sizes were statistically significant, which shows that the ITSs had a positive impact on the experimental group. The average combined effect size was .52.

Table 4.2

ITS Effectiveness by ITS Types

ITS Type	Effect Size (Hedges's *g*)	*p*-Value	Overall Heterogeneity (Q-Value)
AutoTutor	.62	.129	6.95
ALEKS	.32		
ElectroniX-Tutor	.57		
Why/Atlas	.59		

ITS Type	Effect Size (Hedges's *g*)	*p*-Value	Overall Heterogeneity (Q-Value)
CognitiveTutor	.72		
eXtended Tutor	.47		
Combined ITS	.40		

The effectiveness of ITSs was tested on different ITS. The most common ITSs studies were found on AutoTutor, ALEKS, Why/ATLAS, and CognitiveTutor. The rest of the ITSs were combined as one group for better evaluation purposes. CMA software combined the like studies and gave the results as the corresponding group (ALEKS, AutoTutor). The average effect size of all ITSs combined, with random effect modeling, was .53, at *p*-value = .129, and Q-value = 6.95. This result interprets that the combined effect of different ITSs had an above moderate learning influence on the learners.

Table 4.3

ITS Effectiveness by Subject Types

ITS Subjects	Effect Size (Hedges's *g*)	Overall *p* - Value	Overall Heterogeneity (Q)
Algebra (CognitiveTutor, PAT)	.67	.239	6.67
Statistics (ALEKS)	.39		
Mathematics (AnimalWatch)	.63		
Engineering (ElectroniXTutor)	.59		
Physics (Why/Atlas)	.41		
Medicine (ACLS Cardiac Tutor	.68		
Computer Science (ACT-Tutor)	.52		

To check the ITSs effectiveness based on the subject matter, the same subject ITSs were combined. The CMA software reported the random effective size ranged from g=.39, for ALEKS, to g=.68 ACLS Cardiac Tutor. The average combined result was g=.55, with an overall

p-value =.239 and a Q-value of 6.67. The computed results showed an above moderate impact of the ITSs, with a significance of .239 and heterogeneity of 6.67.

Table 4.4

ITS Effectiveness as the Mode of Intervention

ITS Type	Effect Size (Hedges's *g*)	Overall *p* - Value	Overall Heterogeneity (Q-Value)
ITS - Only	.84	.171	6.57
ITS - Blended	.27		
ITS – Supplement	.73		
ITS – Lab	.59		
ITS - Assignment	.31		

Different modes of interventions, ITS-Only, ITS-Blended, ITS-Supplement, and others as ITSs, were used. The average effect size of .55 shows that the results were moderate and very close to other ITS-based learnings. The heterogeneity value of Q=6.57 and p-value (p=.171) were also a close match.

Table 4.5

ITS Effectiveness with Moderators

ITS Moderator	Effect Size (Hedges's *g*)	Overall *p* - Value	Overall Heterogeneity (Q)
Teacher (Blended)	.63	.004	5.42
Study Time	.57		
Assessments	.59		

Moderators like teachers in the class facilitating learning with ITS, duration of study times, and types of assessments embedded in the program or feedback helped learners in their studies. The average effect size of moderators in ITS learning was .58, with an overall *p*-value of .004 and a Q-value of 5.42. Another result of positive effect size.

Table 4.6

ITS Overall (Pooled) Effectiveness

Random-effects Model	
Overall Effect Size (Hedges's *g)*	.53
Overall *p* - Value	.073
Heterogeneity Value (Q)	34.27

Table 4.6 depicts an overall combined pooled effect size of g = .53, with an overall p-value of .073 and Q -value of 34.27.

Discussing the Findings – SSM Approach Conclusions

The purpose of this paper is to recommend a solution for a complex problematic situation using a soft system approach. The system of interest is the illiterate population in the world. The SSM approach was considered in finding a solution for millions of deprived school-aged children with quality education. Besides, brick-and-mortar schools, real-world technologies like MOOCs, online education, mLearning, eLearning have not produced very significant results. The COVID pandemic also has a very devastating effect on children's education. It is reported that tens of millions of them may not return to schools. As educators, we have to come out with a system that reaches those students and provides personalized teaching, with techniques with student engagement, timely feedback, and unbiased assessments. This structured education may not be possible without the integration of artificial intelligence and machine learning systems.

A conceptual framework was evaluated in the form of an Intelligent Tutoring System. The ITS depicts a human tutor, develops customized lesson plans, its virtual pedagogical agent tutors while engaging students with a two-way dialog. Furthermore, it strategically modifies lessons based on students' mastery levels. Of course, there is no substitute for a human teacher, and human tutoring positively impacts student learning (d=.79) Graesser et al., 2011). But when

a human tutor is not an option, an ITS may be a practical possibility.

The results of the above meta-analysis show (Tables 4.1 to 4.5) that the ITSs have produced above moderate effect sizes in multiple comparison studies. On a combined average, Table 4.6 shows that the ITSs had an overall pooled impact of g=.53 effect size on multiple sampled populations. The other precise meta-analyses also displayed close to the same effect on students. However, it may be noted that studies have been done only in university/laboratory settings and not on the targeted population. Hence there is a need to evaluate this methodology in the affected regions before involving educational organizations to implement ITS as a teaching tool. In addition, regulations and guidelines have to be evaluated and a measure in the sixth step of SSM.

Limitations of this SSM Study

The SSM approach requires engaging all stakeholders in all stages of fact findings, real-world system evaluation, conceptual system building, and implementation with mutual consent. Major stakeholders in this soft system analysis are the students themselves or their representatives, educational organizations, governmental agencies, and educators. Due to the meta-analysis structure of this study, all the parties in the system of interest could not be involved. On the other hand, the implementation phase (phase 7) requires an assessment of the intervention. Any uncertainty, limitations, shortcomings, and improper execution practices were not evaluated since there was no data available on the mass implementation of the ITS program. The study stopped at phase 6, “the feasible changes identified.” The conceptual framework of ITS is very expensive to develop and is left for future development.

Suggestions for Future Studies/Development

Most of the work on ITS has been done in labs or universities. It has not been deployed

as the main form of instruction in any school. Just like the convenience of online education, ITS has the advantage of anytime, anyplace accessibility. However, the learner may face physiological or psychological problems due to social isolation and lack of physical activity. Communication and social skills, technology addiction, self-discipline, and time management could also become a problem for the ITS users. Research has shown that remote learning can be as good or better than in-person learning for the students who choose it (Burke, 2020). A comprehensives study is needed to analyze the social, cognitive, physical, and psychological effects of ITS as the principal teaching method on children.

So far, the ITS has been implemented as a single subject tutor. To reach students as a full K-12 school system, all the courses need to be combined in the ITS. Integration of individual course libraries with the knowledge base on the cloud would need further research by technological experts. Inclusion of gamification, augmented, virtual, and mixed reality would be helpful concept building and virtual labs for STEM courses.

Conclusion

The meta-analysis has opened a new realm of educational methods to teach millions. It now has added more responsibilities for the educators. As an innovative educational technology, the ITS would require subject matter experts and advanced computer programmers, course developers, instructional designers, educational psychologists, and teachers. The ITS is not as effective as a human teacher, but it can outperform other teaching and learning methods.

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CHAPTER 5

DISCUSSION AND CONCLUSION

In this three-manuscript style dissertation, the empirical research and the corresponding meta-analysis were the requisite of the soft system methodology that was carried out to find a possible solution to educate deprived students in the developing world. The COVID-19 crisis pushed 1.52 billion K-12 students out of school, out of which more than 24 million would never be able to return to schools (Rang-De-India, 2021). In addition, United States Agency for International Development (USAID) reported that 62 million girls are not in school, and millions more are fighting to stay there (USAID, 2020). From Ethiopia to Pakistan, many of them may not be allowed to step into a school due to cultural or social reasons or be forced to marry as illiterate before 18. Educating these underprivileged children is a humanitarian undertaking that the world has to initiate. The three research questions were also being evaluated in these manuscripts.

The first manuscript discussed how the signatory nations of the Universal Declaration of Human Rights (UDHR, 1948) failed to comply with their pledge of providing basic rights to their citizens. The Right to Education is one of the many fundamental rights neglected by most of the developing world. The review work found that since none of the UNO's members have revoked the UDHR for more than 60 years, it has become a customary international law (Shaw, 2003). UNESCO (2019) reported that failure to the Right to Education obligation resulted in 775 million illiterates in the world. This manuscript discussed the importance of educational technology in the fight for illiteracy. Later, an analysis of MOOCs as a learning platform for educating the masses was carried out. Next, it examined the advantages of this free educational portal and its limitations due to an unstructured education model for school-age children. A case was built for the Intelligent Tutoring System (ITS) as a viable educational technology

intervention. Finally, the components of the virtual pedagogical agent, Digital Tutor (DT), the face of ITS that interacts with the learner, and its components were discussed. Adding the AI-based voice cloning technology to the DT was debated as a motivational tool to engage students in the learning process.

The second manuscript discussed the importance of student's engagement in the lesson for meaningful learning. There is a positive correlation between behavioral, emotional, and cognitive engagement and academic success (Delfino, 2019). Engaging students in the lesson enhances students' focus and attention on the concept, deepens critical thinking, clarifies novel concepts, and helps motivate and self-esteem. Furthermore, psychological and cognitive elements were elaborated. Emotions, fear of failure, frustration due to the non-clarity of the concept, anxiety, and depression may lead to boredom and disengagement from the learning process. The ITS is created to replicate a human tutor in a student-centered adaptive teaching/learning environment. In this chapter, a good deliberation was made on how the DT, the virtual pedagogical agent (User Interface Model of an ITS), reengages the learner with the lesson with a two-way dialog using gaze patterns, emotion recognition, voice recognition, and voice cloning technology.

The third manuscript explained how humans' innate characteristic, the learning agility comes into play when they don't know what to do in a complex situation. In the complicated illiteracy problem, the SSM approach was invoked by the learning agility to evaluate the problematic situation. SSM's seven-stage procedure was applied in finding a potential intervention in educating such a huge population of children. The seven stages of SSM are; 1) Contemplating the complex system of interest (SOI) and accepting that it is a problematic situation (the widespread illiteracy issue), 2) Express the problematic situation (deprived school-age children), 3) Explaining the root definitions of the current real-world approach to fix the

problem (using MOOCs, and other educational technologies to help educate those children), 4) Presenting the conceptual model, as the alternate intervention due to lesser success rate of real-world practices (introduction of ITS), 5) Analyzing conceptual model and comparing it to the real-world model/s (ITS vs. MOOCs), 6) Identify the conceptual model as a feasible intervention (application of systematic research, meta-analysis, etc.), 7) Taking action to improve the problematic situation (implementation of ITS with mutual consent of all stakeholders, and evaluating the intervention).

To answer the first research question; Whether an ITS could be used as a viable intervention to deliver education in the developing world? A case was built for the ITS as a possible intervention in the SOI. A meta-analysis was run on its effect size as a learning tool. Overall combined effectiveness of the ITS was revealed in the third manuscript. Multiple comparison models, different ITS types, and moderators disclosed a moderate pooled effect size Hedges's g = .53 on the sampled experimental group. The results showed that an ITS could be a valid contender as an education delivery system.

The contribution of this dissertation might have the following impact on the educational technology integration in education delivery: 1) a comprehensive literature review with a solid discussion of multiple technology systems could be a positive effort against illiteracy fight, 2) opening a new realm of educational technology research and development, 3) an alternate educational system, that has a substantial record of educating people without human intervention, 4) an application of effective metacognitive strategy and educational pedagogy in an AI-based learner-centered framework.

The research studies discussed in these manuscripts show a human effort to eliminate illiteracy, which has plagued millions of fellow human beings. Oscar Lewis (1966) very realistically postulated that the culture of poverty and illiteracy, once started, is likely to continue

into generations unless there is outside intervention. Thus, this research is expected to change the lives of millions of poor and devasted children in the world. It is also anticipated that it will incite more research in educational technology that will ultimately make the world a more peaceful place to live.

The practical aspects of the conceptual framework list a complete directive to implement this educational system. This American accredited system would regulate the educational industry and motivate students to adopt it. Award of a recognized completion diploma would open doors of higher education for the beneficiaries. Recognizing the good effort might inspire the illiterate adult population to take advantage of the system. The ITS technology could also be used in a trade or vocational training program, thus promoting unemployed adults' employability skill set. The Education Dominance program of the Defence Advanced Research Projects Agency (DARPA) is a good example. The program implemented the ITS-based computer network education program and successfully trained non-technical US Navy personnel (Kulik, & Flecher, 2016). A very challenging competition was held between the Education Dominance graduates and other fleet experts with an average of 10 years of experience. The new graduates outclassed the professionals in every class of test (Casebeer, 2012).

Besides further research, the program needs to be implemented first in critical regions, like Sub-Saharan Africa, where the illiteracy rate has seen its lowest in the world. Nevertheless, this framework in the theoretical aspect provides helpful directions in constructivist digital pedagogy, making a reasonable contribution in the education field. To positively impact the illiteracy problem, there is a need for a serious collective effort from the governmental and philanthropical agencies, research and science community, and academia.

Overall Limitations

This dissertation presents a very enthusiastic goal to accomplish. Reaching millions of students would be a worldwide effort. The development phase of the SSM approach would require many experts in the field. To name a few, subject matter specialists, instructional designers, course developers, graphic designers, advanced computer programmers, network specialists, cloud-based programmers, cybersecurity experts, database administrators, educational psychologists, support staff, managers, administrators, and the list goes on. But no difficulty holds any merit in the fight to eradicate illiteracy. The only thing that is needed on the world's part is the willingness to improve this complex situation. The motivation is there; all it needs is cooperation and coordination from all stakeholders.

The three studies have their shortcomings. The first manuscript blamed the illiteracy problem mostly on the UDHR nations. Other socioeconomic and environmental problems faced by these developing countries were not discussed, but they contributed heavily to illiteracy. Overpopulation, poverty, hunger, civil restlessness, human migration, cultural and religious discrimination, poorly managed education system are the main constraints. The cost associated with ITS development, which is also a hindrance in ITS deployment, was discussed briefly. At the same time, the cognitive task analysis, setting up problem-solving strategies, integrating multiple components, testing before deployment, and commissioning the production model could prove very time-consuming and costly. The second manuscript discussed engaging students with ITS. Zoning out using gaze recognition, emotional and facial detection, and voice cloning need much computational power at the user's end. It also requires a lot of data transfer to and from the ITS server. Lack of Internet, slow data transfer rates could prove to be the bottleneck in the learning process.

The third manuscript deliberated the SSM model in finding a solution to the illiteracy issue. The stakeholders' points of view in this SSM approach were not considered. The study stopped at phase 6, "the feasible changes identified." Thus the SSM model was not completed. On the other hand, the implementation phase (phase 7) required assessing the intervention (Checkland, 1990). Any uncertainty, limitation, shortcomings, and improper execution results of this stage could not be discussed due to the nonavailability of related data.

The meta-analysis in the third manuscript reported small sample sizes in most of the studies. In addition, there were a few unpublished reports available on the subject, which is why the publication bias was not analyzed efficiently. A computer analysis would have been ideal, but due to the limitation of Comprehensive Meta-Analysis software, the funnel-graph could not be plotted against the size of the ITS treatment effect. So instead, publication bias was examined manually by reviewing the available research material.

The comprehensive literature search revealed that most of the ITS research had been carried out on adult learners. Very few studies were targeted school-age children. These findings signify many limitations in this educational intervention, but the ITS advantages outperform them easily. The technology can reach distant places, apply adaptive learning, personalize lesson plans, and engage students in the learning process digitally by building a rapport with two-way dialogue. This could be the best alternative for underprivileged students who are deprived of quality education.

Recommendation for Future Studies

We understand that past performance can foresee a favorable behavior, though; it is not always a reliable method. The ITS has established a positive affinity to teaching with AI, but it would require further evaluation. The ITS being discussed here as a possible human tutor

replacement needs to focus more on personalized learning, motivation techniques, and informative feedback to young learners. The comprehensive literature review indicated that most of the research on ITS had been done in controlled settings of universities, labs, or governmental organizations. In addition to that, the ITS had been tested as a single subject tutor. The ITS has not been implemented as a full education delivery model to K-12 students. More research and development of ITS are needed to integrate all grade-level courses in the knowledge base of the Domain Model. Furthermore, the addition of huge data (all courses), strategies, students' data, and files would require a tremendous amount of storage.

Similarly, the ITS server would require massive crunching power, and ordinary computers would not be able to handle such a heavy load. Therefore, the researchers would have to come out with solutions as used in technologies like IBM "Watson," Amazon "Lex, Comprehend, & Dialogflow), and Microsoft "Bot Framework, and TensorFlow." Future research would also be needed in cloud storage for course libraries and data compilation and cloud computing for ITS operations.

Other areas of future research can benefit from further studies on privacy management, cybersecurity, data analytics, report management, ITS automation, and disaster recovery. In addition, integration of gamification, augmented, virtual, and mixed reality virtual labs would be helpful in concept building in STEM-related courses. For example, the DT could be replaced with human-like holograms in education (Khan, Mavers, & Osborne, 2020).

Since ITS has never been used as the principal education delivery model, no regulations and guidelines are set up yet. Work needs to be done by the governmental education agencies on the accreditation policies and academic standards to award recognized completion diplomas to students.

To answer the research question; What are the challenges in delivering this educational technology in developing nations? The following may have a feasible solution, which would require further research in the area.

The ITS relies heavily on the Internet, Wi-Fi, or cellular networks to deliver content. These facilities are not available in many regions of the world. Tech giant Google started a free Internet initiative in India named "Next Billion Users" (Duau, 2016). This program was later extended to 5000 other regions in Mexico, Brazil, Thailand, Vietnam, and South Africa (Bonifacic, 2020). Other tech companies like Facebook came out with the same kind of program, "Free Basic Initiative." Some of these free programs were shut down by the concerned governments due to inappropriate resource use (Singh, 2020). These programs could be revived and expanded to other regions for educational use with reasonable restrictions.

Another education delivery option is the cellular network. The world association of global network operators, GSMA, reported 747 million cellular subscribers in sub-Saharan Africa, 75% of the population (Elliot, 2019). Another report by Mary Fogerty (2018) reported Education & Science that more than 789 people use mobile phones in African countries. The number is second to the Asian continent. The cellular networks' digital transmission uses frequencies range from 700MHz to 2100 MHz.

In contrast, the public safety spectrum uses frequencies below 700 MHz (FCC, 2021). Once the ITS builds its credibility as a viable educational system, the international community can be convinced to use a segment of the public safety spectrum. However, this may be a long shot and would need an international communication policy change.

In many backward regions, cultural restrictions that hinder female education could benefit from an ITS-based education, but the phenomenon has not been evaluated. Future studies on this technology's effectiveness would help build a rapport, and tribal elders could be

convinced to educate their female population. On the other hand, cultural and social differences, authoritarian practices of governments, uneducated regions where conventional education methods are not available, this mode of education delivery could be helpful. Therefore, we need to evaluate this system in our future studies further. Moreover, the lack of studies on school-age children prompts more research ITS like Cognitive Tutor (Algebra Tutor).

Lastly, future research would need a series of systematic strategies concerning the seven stages of soft system methodology to help eradicate illiteracy among millions. Then, the research results and recommendations could be used by the concerned to prepare a robust and viable solution to the illiteracy menace.

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